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CALIFORNIA STATE
THE Mining Bureau.
SAN FRANCISCO.

MINING INSTITUTE

OF SCOTLAND.

TRANSACTIONS,

Vol. V.

1883-84.

HAMILTON:
PRINTED BY WM. NAISMITH, CAMPBELL STREET.
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THE MINING INSTITUTE OF SCOTLAND.

ANNUAL MEETING.

THE Sixth Annual Meeting was held in the Hall of the Institute, Hamilton, on Thursday, the 12th day of April, 1883—

Ralph Moore, Esq., Ex-President in the Chair.

Upwards of 50 Members were present.

The Secretary read the Minutes of the last General and Council Meetings. They were approved of, and signed by the President.

FINANCIAL REPORT.

Mr R. T. Moore read the report of the Auditors, which was as follows :—

THE MINING INSTITUTE OF SCOTLAND—BALANCE SHEET.

Dr. **Abstract of Receipts.**

1882-83.

To Balance from last year,	£117	5	0
„ Members' Subscriptions,	289	3	0
„ Do. do., paid in advance,	3	14	0
„ Do. do., arrears for last year,	2	2	0
„ Advertisements,	17	10	0
„ Do. arrears,	12	12	0
„ Sale of Transactions,	11	1	11
„ Rent of Hall,	2	11	0
„ Interest on Money in Bank,	4	13	10
	£460	12	9

Cr. **Abstract of Payments.**

1882-83.								
By Printing and Stationery,	...	...	...	...	...	£171	17	0
„ Rent for Hall, ...	...	...	...	...	...	14	13	7
„ Cleaning Hall, ...	...	...	...	...	...	2	10	0
„ Taxes and Insurance, ...	...	...	...	...	...	3	1	1
„ Stamps, Trains, &c., . .	...	...	...	...	...	13	17	8
„ Deputation to England,	...	...	...	...	...	15	3	9
„ Books and Bookbinding,	...	...	...	...	...	8	2	11
„ Salaries, ...	...	...	...	...	...	50	15	0
„ Balance in Bank,	...	...	...	...	...	180	11	9
						£460	12	9

5th April, 1883.—Examined, compared with vouchers, and found correct.

(Signed) ROBERT THOMAS MOORE, } *Auditors.*
(„) THOMAS ARNOTT, }

Assets.

By Money in Bank,	...	...	...	...	...	£180	11	9
„ Members' Subscriptions in arrear,	...	...	...	...		15	13	6
„ Books in Library (not valued),	...	...	...	...				
„ 2370 Copies of Transactions (not valued),	...	...	...					
						£196	5	3

Liabilities (Nil).

Balance, ...	...	...	...	...	...	£196	5	3

JAMES GILCHRIST, *Secretary.*

The CHAIRMAN, after the reading of the report, remarked that the Institute was still in a very healthy state. It seemed to bear out the remark he had made frequently before, that they would not go down for want of money.

COUNCIL'S REPORT.

The Secretary read the following Report by the Council :—

YOUR Council have pleasure in reporting that during the past year the Institute has progressed steadily, and is still—at the close of the fifth year of its existence—in a satisfactory condition.

The increase in membership, although substantial, is under that of the preceding year. During the past year 45 new members joined; but, as 5 retired, 4 died, and 12 were struck off

owing to arrears, the net increase is 24, making the total on the books at the end of the year 411, as compared with 387 in the previous year.

During the year a circular, setting forth the aims and work of the Institute, was sent to those owners, managers, and others in the mining districts of Scotland, who had not become members; and this was probably the means of inducing many to join. Your Council, however, feel convinced that a much larger increase will take place when the value of the Institute becomes better acknowledged amongst the mining and engineering professions and trades.

With the exception of the August meeting, held at Stirling, the monthly meetings were all held at Hamilton, and the attendance was fully maintained.

Various subjects, some of great importance, and all interesting and instructive, were brought forward by papers read before the Institute. These papers, and abstracts of the discussions thereon, have been printed and published in your Transactions, and embrace the following subjects :—Explosions of Fire-Damp, Mining in Germany, Annealing Chains, Shocks in Pumping, Coal Dust, Signalling by Endless Wire, Blasting Gelatine.

The lecture on Electric Lighting, kindly given by Principal Jamieson, was by your permission made public, and was attended by a large number of persons. The lecture, illustrated by 18 plates, was published in part 12 of the Transactions.

The other matters which have engaged the attention of members include Safety Lamps, upon which a committee reported the results of experiments as to their lighting power and relative cost. A new safety lamp was exhibited and explained by the inventor, Mr Ballardie, Glasgow; and a report will shortly be made upon it by a committee.

The report by the deputation to Shipley Colliery, Derbyshire, to examine the process of getting coal by the use of compressed lime cartridges, was issued, and subsequently the results of experiments made in this district were communicated to the Institute.

The interchange of Transactions with other Institutes has been continued, and these books, together with new volumes of scientific

and other useful books purchased during the year by the Institute, are placed in the library. During the last nine months members have had the opportunity of taking books from the library for perusal at home.

With the general welfare of the Institute in view, the Council would urge members who have not hitherto prepared and read papers to assist in this matter.

John Austine, Esq., presented the Institute with a book entitled —"Mechanical Engineering," by C. M. Percy.

There have been 19 meetings of Council during the year.

The CHAIRMAN again referred to the flourishing state of the Institute, and said their only want was plenty of papers. They must have that in order to keep the thing going.

The following gentlemen were balloted for and admitted as Ordinary Members:—

ALEXANDER CAMPBELL, Manager, Burgh Colliery, Irvine.
ALEXANDER HILL, Mining Engineer, Barrancos, Portugal.
JAMES THORNTON, Coalmaster, Hermand House, West Calder.

Other five gentlemen were nominated, and will be balloted for at next Meeting.

The following gentlemen were elected Office-Bearers for Session 1883-84.

President:

JAMES M'CREATH, Mining Engineer, 95 Bath Street, Glasgow.

Vice-Presidents:

JAMES S. DIXON, 170 Hope Street, Glasgow.
JOSEPH T. ROBSON, Jesmond Villa, Cambuslang.
JAMES SMART, Angus Lodge, Hamilton.
JAMES BARROWMAN, Portland Park, Hamilton.

Councillors:

DAVID ANDERSON, Clydesdale Street, Hamilton.
JOHN AUSTINE, Oak Lodge, Hamilton,
ROBERT BEITH, Town Lands Colliery, Hamilton.
ARCHIBALD BLYTH, Bent Colliery, Hamilton.
JOHN DRINNAN, Arden Colliery, Airdrie.
JAMES HASTIE, Greenfield Colliery, Hamilton.
JOHN HOGG, North Motherwell Colliery, Motherwell.

JOHN LOVE, Haughhead Colliery, Hamilton.
ROBERT T. MOORE, Croft Villa, Rutherglen.
ALEXANDER M'CALLUM, Niddrie Collieries, Portobello.
JAMES PRENTICE, Browmieside Colliery, Airdrie.
HENRY TELFER, Overtown and Law Collieries, Wishaw.

Ex-Officio Members of Council.

GILBERT BURNS BEGG, Brandon Street, Motherwell (Past President).
RALPH MOORE, Croft Villa, Rutherglen (Past President).
JOHN M. RONALDSON, Belton Villa, Pollokshields (Past Vice-President).

THE NEW PRESIDENT.

The CHAIRMAN—Gentlemen,—On resigning the chair which I have so unworthily occupied for the last three years, and which it is my duty now to vacate, I desire to thank you for the kindness you have shewn me in overlooking many of my shortcomings while endeavouring to do the best I could to conduct the meetings over which I had the honour to preside. It is indeed a high honour to be President of such an Institution as this, and any one should feel proud to be in the position. The mining industry in Scotland is a very large one. There are now 610 mines, employing 67,906 persons, and last year they raised 24,349,481 tons of mineral. It is the object of this Institute to apply science in the mine, so as to lighten the toil, and lessen the danger to this army of workers. It is indeed an object worth striving after. I feel certain that the Institute has already done good in this direction, and as it progresses in numbers and abilities we may hope to do much more. It has been found desirable in all scientific societies to change the Presidents from time to time. The object is that the honour should be duly shared among the members, and the infusion of new blood is invariably beneficial to the society. This, your Council have, as I think very wisely, advised, and you have decided, and I have the greatest pleasure in resigning the chair to Mr M'Creath, who I know will worthily fill it. It has been a great pleasure to me to have presided at your meetings and to have seen the Institute increasing from small beginnings to its present membership of four hundred. I have had both pleasure and profit in attending the meetings, and I hope still to profit by those which have to come. I have again to thank you and to wish the Institute every success. My duty now is to vacate the chair in favour of Mr M'Creath.

Mr M'CREATH having taken the chair, said—I have to thank you for the high honour you have done me in electing me to be your President. I could have wished your choice had fallen on one better able to perform the duties, but I rely on the zealous assistance of the Council and the support of the members generally. I am very much obliged to the ex-President for the kindly way in which he has spoken of me. I hope for the current year the prosperity of the Institute will be maintained. It certainly has very greatly increased under the leadership of our ex-President. There is so much business to do to-night that I shall not detain you by any further remarks.

THE LOCALE AND NUMBER OF MEETINGS.

Mr J. S. DIXON rose to make the motion as to decreasing the number of meetings held annually, of which he gave notice last month. He said ever since the Institute was started there had been a general feeling expressed at various meetings that the Transactions were not delivered to the members in time to allow them to peruse them so that they might discuss them at the following meeting; and that had been met by the Council and Secretary by the statement that there was not sufficient time between the meetings for doing so. Another point—and a more delicate one:—he thought they were exhausting the subjects too quickly. The North of England Institute had twelve meetings for many years, but they had lately reduced them to six with very great success. He wrote Mr Bunning, the secretary of that Institute, to let him know the number of meetings that other kindred institutions held; and he replied that the Chesterfield Institute held four meetings in the year; North Staffordshire, six; South Wales, four; Mechanical Engineers, four; Midland Institute of Engineers, six. Taking their Glasgow Societies: the Institute of Engineers of Scotland had seven meetings; the Geological Society, six; and the Natural History Society, seven. From these two points of view, he thought it desirable to reduce their meetings. He had learned since last meeting that many members were averse to there being only six meetings in the year, and with the consent of the meeting he would modify his motion. He begged to move that there be nine meetings held annually.

Mr ARCHIBALD BAIRD seconded the motion.

Mr DUNDAS SIMPSON, in making the motion of which he had given notice—viz., that the meetings of the Institute be in future held in Glasgow—stated his belief that, if the place of meeting was altered as he proposed, there would be less difficulty in getting papers to be read; that greater travelling facilities would be afforded to members in the east, north, and west; and that, in consequence, the attendance would be larger and the discussions better.

Mr DRINNAN seconded Mr Simpson's motion.

The SECRETARY stated that meetings that had formerly been held in other districts than Hamilton, for the convenience of members in these districts, had not been attended as was expected, but that the bulk of those present had come from Hamilton district.

Mr SMART moved the previous question. The time might come when it might be necessary to lessen the number of meetings; but, so far as they had gone, they had been very successful, and this, he believed, was due to their regular monthly meetings. With reference to the proposal to change the place of meeting to Glasgow, he reminded them that they were standing in the centre of the largest mining district in Scotland, and, looking over the list of members, he found the largest number who attended the meetings were from that district.

Mr BEGG seconded Mr Smart's amendment.

After considerable discussion, in the course of which it appeared that most of the members present were favourable to some at least of the meetings being held in Glasgow, but thought that the number might be left with the Council to determine, the following modification of the motion of Mr Dixon was carried by a majority, viz.: that there shall be nine ordinary general meetings in each year to be held in Hamilton, unless elsewhere arranged for by the Council.

CALIFORNIA STATE

DISCUSSION OF MR GARDINER'S PAPER ON THE PART PLAYED BY COAL DUST IN EXPLOSIONS OF FIRE-DAMP.

The PRESIDENT suggested that, in discussing this paper, the subject of spontaneous combustion of coal should not be pursued further than was necessary for the consideration of the part played by coal dust in fire-damp explosions, because a paper was to be read on the spontaneous combustion of coal in ships, in discussing which a thorough consideration of spontaneous combustion was desirable, and it would be inconvenient to be going over the same ground twice.

Mr DRINNAN—Is there any further communication from Mr Gardiner about his paper?

The SECRETARY said that since last meeting he had a communication from Mr Gardiner saying he was leaving the country, and could not be present.

Mr ROBERTSON—Does that mean he has resigned?

The SECRETARY—I take it for that.

Mr DRINNAN drew attention to statements in the paper which, in his opinion, had not been maturely considered, and had been brought before them in a defective manner.

Mr BARROWMAN said from the first two paragraphs of that section of Mr Gardiner's paper, entitled "Results of Experiments on Coal Dust" one would be led to believe that the effect of coal dust in connection with explosions was first known about the years 1872 and 1874. Of course this was not the case, and it was as well to refer to it. In the Preliminary Report of the Royal Commissioners on Accidents in Mines it is stated that Faraday and Lyell directed attention in 1845 to the influence which may be exerted by deposits of coal dust in mines upon the magnitude of explosions.

Mr R. T. MOORE said there was also a point which Mr Gardiner had not noted—although perhaps it did not, strictly speaking, belong to his subject—viz., that dust did not require to be coal dust in order to make a mixture of gas and air explosive, but that any other fine dust would do almost equally well. A mixture of gas and air which was not explosive—in fact one in

which the gas could not be detected with a Davy lamp—would be rendered explosive if fire-clay dust, magnesium dust, or any other fine dust were present in sufficient quantity. This was a very important point, and introduced an element of danger even in a mine perfectly free from coal dust. It appeared from the experiments made by Professor Abel that the part played by coal dust was more that of extending the effects of an explosion than of originating it. It might lengthen the flame caused by a blown out shot, but there was a general feeling that there would not be an explosion with a mixture of coal dust and air alone.

The PRESIDENT said this was perhaps the most important and difficult subject that could be brought before them at the present time. He was afraid they would not be able to get much important information before the report of the Royal Commission was issued. In addition to Mr Drinnan's remarks on the statement in the paper of the heat evolved by an explosion of fire-damp he would say that the author had omitted to deduct the 966° of latent heat. The quantity of water heated by 1 lb. of gas should be 21 lbs. from the temperature of 62° to steam at 212°. He had gone roughly into the calculation of the heat which may be expected from the ignition of a perfectly adjusted mixture of air and gas in a mine and considered it highly improbable that the floor could be so heated by it that damp salt there would be decomposed or even sublimed in appreciable quantity. In closing the discussion, he proposed a vote of thanks to Mr Gardiner for his paper. They must all acknowledge the industry he had displayed in studying the subject and laying the result before them.

DISCUSSION OF MR DRINNAN'S PAPER,—"IS BLASTING GELATINE, AS HITHERTO MANUFACTURED, A SAFE EXPLOSIVE?"

The PRESIDENT, in introducing the discussion on this paper, said it was likely that what the author had so clearly stated here

had awakened the desire of the members to learn more of the qualities of this explosive, and of the difference between the manufacturers and the Government officials.

Mr SMART said, when he read Mr Drinnan's paper, the first question he asked himself was :—What were the restrictions the Government placed on the manufacture of blasting gelatine? He could not see that this information was in the paper, and he was rather at a loss; but he came to the point yesterday in the remarks of the Chairman of Nobel's Explosives Coy. (reads)—

"I wish to say a few words on the subject of blasting gelatine, which is not referred to in the report. On 27th October last we had an accident in the drying stove of the nitro-cotton department while preparing material for the manufacture of blasting gelatine, unfortunately involving the loss of two lives. No blame was attachable to the company, and the Government Inspector at once authorised the rebuilding of the stove on the same principle. We believed, however, that another and safer plan of preparing the nitro-cotton could be adopted, and we therefore delayed re-erecting the stove. Meantime, we were called upon by the Home Office to undertake that our blasting gelatine should pass certain tests, particulars of which up to the present time have been withheld from us; and we thought it advisable to refrain from issuing any of this compound to our customers till the test-question had been arranged to the mutual satisfaction of the Home Office and the company. I have no doubt that, when fairly understood, this little difficulty will be overcome, as we have every reason to believe that the Home Office is desirous of meeting fairly the wishes of the mining interest generally, the more especially as Sir Frederick A. Abel, C.B., in a lecture delivered in Glasgow, on the 1st of last month, described blasting gelatine as the most perfect form of explosive compound with which chemists were acquainted."

There was no doubt that this was one of the best explosives known, and he had no hesitation in saying that this little difficulty would be overcome; but he believed Mr Drinnan's paper would be of very little service, because the Institute could not move in any way to try and influence the authorities at the Home Office to withdraw their restrictions when the whole thing was under consideration. Nobel's Coy. seemed perfectly satisfied themselves with the delay that had taken place.

Mr DRINNAN was afraid Mr Smart assumed too much in assuming that Nobel's Coy. were perfectly satisfied with the matter remaining in abeyance. He submitted that what Mr

Smart had read did not contain the real reason why they were no longer manufacturing or retailing the explosive. They withdrew everything, and refused to issue any more until the proper test had been determined; and he was inclined to think that Mr Smart had not read the paper,—he should hardly call it his paper, as it was a reproduction of the evidence,—so carefully as was desirable, for at p. 323 it would be found, in reference to the test Dr Dupré subjected the gelatine to, that the Sheriff said—"It exceeded the bounds of reasonable probability." That was one of the things Nobel's Coy. objected to. The Government, in fact, said they were to manufacture gelatine to satisfy those tests which Dr Dupré subjected it to, and until an arrangement had been made, which they felt they were perfectly able to comply with, they declined to go on any further with it. That appeared from the various correspondence. They were awaiting the result of the applications of mine owners in England and Wales to the Home Secretary asking that the manufacture should be continued, and all his paper asked was that they should not be behind-hand in requesting the Government to place no needless restrictions on its manufacture. That was all the object he had in view in first mentioning the matter; and, in deference to the wish of Mr Moore, he had prepared those few remarks in order that members might be in the same position as himself, with regard to forming a judgment in the matter.

Mr SMART said his impression was that, from the exudation that had taken place, they had not reached the perfect way of making the gelatine. If he was right, there was a slight exudation from one of the cartridges. Was it not possible that Professor Abel and Dr Dupré thought it should be manufactured in such a way that no exudation should take place?

Mr DRINNAN said when Dr Dupré was examined, he maintained,—indeed, this was the essence of the prosecution,—that there had been both liquefaction and exudation; but, in cross-examination, the Doctor said he would scarcely claim that there had been liquefaction. Counsel then maintained that the whole question had been given up, because blasting gelatine was a chemical combination, and it had not been proved that the original ingredients had separated, without which exudation was impossible.

The PRESIDENT understood that the circumstances under which this trial arose were that a cartridge of blasting gelatine was, on account of its suspicious appearance, taken out of a magazine by the Government inspector, and, after being exposed 24 hours to a temperature of 14° Fahr., was the next 24 hours exposed to a temperature of 80° Fahr.; a substance then exuded from the cartridge which was as dangerous as pure nitro-glycerine. Now 14° is about the temperature of our coldest winter nights, and 80° that of our warmest coal mines. It was unlikely that there would be 24 hours continuously at 14°; but if there were say 12 hours, then what was asked in the trial was only a factor of safety of 2.

Mr ROBERTSON said this explosive had been withdrawn from the market before for the very same reason. Nobel's people were quite aware of the test it was to be subjected to.

Mr RALPH MOORE asked if the length Mr Drinnan wanted them to go was not this: There were some government experiments going on as to the nature of this explosive, which had, as he thought, been unduly delayed, and he wished an expression of opinion from the Institute that the Government should not delay but as soon as possible produce this test, so that this explosive could be got into use again.

Mr DRINNAN said this was so.

Mr R. MOORE—That is a point upon which the sense of the meeting might be taken.

The PRESIDENT—Possibly, before putting that, it might be advantageous if Mr Drinnan would explain what he referred to near the bottom of p. 321 (reads). What was this non-viscous state?

Mr DRINNAN—It would be the proportions of the ingredients which might make it viscous or non-viscous, and it was one of the points of the defence that it was more safe as Nobel's Coy. manufactured it than as Dr Dupré would wish to have it manufactured. He would wish to have it made very stiff. Nobel's Coy. maintained that were it made as Dr Dupré desired, in a stiff state, some of the material might remain unexploded. This was the evidence given by Professor Dewar of Cambridge, and others agreed with him in saying that it was more safe in that viscous state than in the state in which Dr Dupré desired to see it.

Mr ROBERTSON said the matter resolved itself into a chemist's dispute. With reference to the exploding after the main portion had exploded, they had an example of this in Glasgow where some damage had been caused by a second explosion. At present there was an action in the Court of Session by a workman who claimed damages in respect of one of these explosions.

Mr DRINNAN said he thought the gentleman who made such a statement ought to give the names of the parties so that the case might be identified; but, whether or not it were a case such as represented, he submitted it had nothing at all to do with the issue he had raised. They did not need to go into the issue between the chemists at all, but simply to ask the Government to place no useless restrictions on the manufacture of this explosive.

Mr BARROWMAN said it seemed if this was a highly valuable explosive it was also a highly dangerous one, and they should not quarrel with anyone who was very careful and anxious in laying down the rules as to the tests to which such an explosive ought to be subjected. He did not know, although it was a valuable explosive and Mr Drinnan had done well in bringing the subject forward, that the Institute was in a position to form an opinion as to this substance, and he questioned the wisdom of going forward with a memorial until they were better informed on the subject.

Mr BEGG said he would just like, without going into the ulterior views of Mr Drinnan, to point out the answer already given. The title of the paper was the question,—Was this explosive a safe one? Now, the decision the Government had come to was that it was not safe, and they had from the evidence in that trial which Mr Drinnan gave, an instance of its want of safety, by the exudation from this blasting gelatine, which was an argument against Mr Drinnan's assertion that it was a perfect chemical combination. No doubt it should be a perfect chemical combination, and if it were this exudation would not take place, but this cartridge proved that some of it was not in that perfectly combined condition which rendered it safe. In the explosion at Burnbank they had an instance of the danger arising from such exudation, and the fact that the Government claimed that it was not hard enough to be safe must

be put against the danger asserted by Nobel's Coy. to attach to this condition. He had no doubt in his own mind that there was great danger attached to the use of this explosive, and he thought Mr Drinnan would not desire any more than the rest of them that undue haste be attached to the manufacture of such a thing until they were satisfied that it would remain safe even in the hands of the most ignorant of them.

Mr DRINNAN said he must protest against the assumption made by one of the speakers that the gelatine had been proved to be unsafe. No such decision had ever been given in any court of law, and no such decision had been given by the Government; and much of the argument, therefore, was based on an entirely wrong assumption. The prosecution entirely failed, and, therefore, he held it had not been proved to be an unsafe explosive. Mr Begg said it was unsafe when hard; so said Nobel's people, and, therefore, they made it soft. Mr Begg said it was a perfect chemical combination. Not so said Nobel's people; it was a physical mixture, and in order to establish exudation Dr Dupré was compelled to use the argument he did, because he could not but admit that there could not be exudation until the original ingredients had again separated. He had looked at some of the gelatine and had seen it used, and he could not conceive wherein it was unsafe to use it. He did not know whether many might have seen it, but it seemed to him a much safer explosive to use than powder. It was no argument to say that some explosion had happened from dynamite. They knew that it was more difficult to keep dynamite in a proper condition than gelatine. He deprecated haste as much as any one, and where life was likely to be in danger he certainly would not like to see undue haste in dealing with this explosive; but the Government might be hastened if the Institute were to take some action in the matter.

Mr HASTIE said if he understood the matter aright, this case was tried and the charge found not proven, but the Government wrote Nobel's Coy. a letter next day asking them not to make any more of it.

Mr DRINNAN—No, no.

Mr HASTIE—They restricted them?

Mr DRINNAN—They said that their tests must still be applied to it, which practically stopped its manufacture.

Mr HASTIE said they were all glad to see precautions being taken for safety, and he did not think the Institute should interfere. More than that, parties might use dynamite with perfect safety, and the Institute should support the Government in these restrictions.

The SECRETARY said when this paper came first before the Council, he came in contact with a member who had used this explosive for some time, and he fully expected a communication from him on the subject. He said they effected a considerable saving by its use.

A MEMBER—In boring?

The SECRETARY—No, in blasting and brushing roads. He thought Mr Drinnan's paper had answered the purpose for which it was written very well; and if it induced any other member to give a paper on other explosives on which there was no restriction, he had no doubt they would benefit thereby. Professor Abel gave a lecture in Glasgow on Explosive Agents some time since, and he had the pleasure of hearing it. He was very much surprised at the great advance made in the power of explosives. Professor Abel, in the course of his lecture, mentioned a resinous gunpowder, and showed a specimen of it. It was made into cartridge form, and he immersed part of one in water with the intention of exploding it at the end of the lecture. The Professor said it was a cheap explosive, and as powerful as common gunpowder. It occurred to him that it might become very valuable for many purposes. They all knew the difficulty of blasting in a damp place, and often shots were lost through the cartridge not being properly prepared. If this resinous powder could be got, it would be a great advantage and effect a saving in mining in wet places, and possibly it might be as well to make inquiries on the subject; and he would suggest that the Council cause inquiries to be made and see what could be done in the matter. After the report of blasting by lime appeared in the papers, he got a communication from a gentleman in Glasgow, calling his attention to a safety blasting powder of which he sent him the samples contained in the box before them.

This powder would not explode unless confined, so that there was no danger of an explosion in the workmen's houses or in the mine. The manufacturers claimed that it was doubly stronger than ordinary blasting powder. He had tried it, but did not find that to be the case. He suggested that a committee might be appointed to inquire into the subject. From the trials he had seen made, he was very well pleased with the results. It could be got either loose or in cartridges, but he thought the cartridges gave the best results.

Mr R. MOORE suggested that the Secretary might give a paper on the subject.

The PRESIDENT afterwards took a show of hands on the proposal to ask the Government not to place any needless restriction on the manufacture of gelatine, and this was negatived by a majority. A vote of thanks was given to Mr Drinnan for his paper.

DISCUSSION OF MR JAMIESON'S PAPER ON ELECTRIC LIGHTING.

The PRESIDENT explained that Principal Jamieson could not be present, but that he would at a subsequent meeting answer any questions that might be put to him.

Mr DIXON thought this was a very good mode for lighting the surface arrangement of collieries. He would like Mr Jamieson to say what light he would recommend them to adopt for that purpose, and what candle-power would be necessary, because he had seen lamps represented as 1000 and 2000 candle-power, which on being tested were found to give under a fourth of what had been given out. If Principal Jamieson, from his experience, could recommend a lamp that would be suitable for the purpose he had indicated, he thought it would be reliable information.

Mr R. MOORE said there was rather little time that night to discuss so important a subject. He very much approved of what Mr Dixon had said, that really very little was known practically, amongst them at any rate, of such lights. How desirable it would be that in the first experiment they made they should get

hold of the very best instruments, and if Principal Jamieson could tell them the very best machine and the cost, without going into the details, it would be advantageous. Many people had tried the light, but there had been hitherto an array of extraordinary failures, amongst some the effects not having been at all equal to what might be expected. As used at Earnock, the light in his opinion had not been a failure, but he for one thought they would have been able to carry it a thousand yards into the face and easily illuminate it. The light had been found to illuminate the bottom of the shaft at a very reasonable cost, still, they expected that it would have done more, and it was desirable to have some facts that they could go upon as to what was the best instrument; what was likely to be the cost; and the effect.

The PRESIDENT said that some months ago he happened to be at a colliery in the south where they lighted the pithead with the electric light, and had done so for a year. The repairs on the dynamo machine had cost about £60. No doubt improvements had been made since by which they would be less liable to go wrong, but it would be desirable to know what was the state of matters in regard to repairs.

Mr JOHNSTONE said he thought they were on the eve of very great improvements on dynamo machines. All their best electricians were working at them. Several patents had been taken out, and he thought those who wanted the thing economically must wait a little. As for Principal Jamieson recommending a dynamo or lamp, it would be altogether out of his place to do so. Those who wished to use electric light must judge for themselves.

Mr DRINNAN thought it would be desirable to have some information as to the amount of heat generated, what was the proper size of wire to prevent it from getting too warm, and so increase the resistance in carrying it any great distance from the machine.

Mr BECKINGSALE, manager and electrician to the Brush Electric Light aud Power Company of Scotland, who was present by invitation, said, in answer to Mr Drinnan, that it was well known that the heat generated in a conductor conveying electricity varied as the square of the current strength, as the time of its duration and as the resistance to the path of the current. It

was therefore an easy matter, on knowing the capacity of the dynamo or battery, and the length and section of the copper conductor, to calculate the increments of heat in any given time in any part of the conductor. But it would be seen that the heat thus shewn to have been generated, though it represented the power lost, did not correspond with the actual temperature of the wire, which was affected by the state of the atmosphere, or other surrounding medium; the thickness and quality of the insulating material; the surface of the conductor exposed as compared with its mass, and other causes. It was an important economy as regards the conductor to keep the current diminished, and to increase the electromotive force when requiring greater power, and this might be effected up to about 250 volts without serious danger or inconvenience, but above this tension it was necessary to take special precautions and to insulate the wire throughout its length, to prevent loss of current and danger from incautious handling. To shew the advantage in economy of greater E.M.F. instead of quantity: take a current of 200 amperes having an E.M.F. of 100 volts, thereby producing, at the dynamo end of the line 1000 feet long, 27 H.-P. The conductor, which is of copper, has a sectional area of ·85 inch, absorbs 2 per cent. of the H.-P., and warms up to about 4° Fahr. above the atmosphere. In increasing the power two-and-a-half times, let it first be done by using a current of 500 amperes, observing the same percentage of loss of power, and the same E.M.F. of 100 volts as before; the sectional area of the conductor will have to be increased to 2·13 square inches, and the power absorbed will be 1·3 H.-P. actual. The other alternative is to raise the electrical pressure to 250 volts, and allow the current to remain at 200 amperes. The conductor can now be reduced to about ·35 square inch in sectional area, the temperature of the wire will increase to about 16° Fahr. above the air, and the H.-P. absorbed will be rather greater, owing to the increased resistance of the line from the higher temperature. Assuming a loss of 10 per cent. of power in the transmission of 100 amperes, E.M.F. 100 volts, the conductor may be reduced considerably, but not proportionately, owing to the increased quantity of heat generated. In the Brush system of electric lighting by arc lamps, it was usual to

transmit 27 H.-P. with a current of 10 amperes, and an E.M.F. of 2000 volts, thus admitting of a much smaller wire of about ·024 square inch in sectional area to carry the current to 40 of their 2000 C.P. lamps at a distance of a mile-and-a-half from the machine; but this force, though high, was only half of that contemplated in the Model Electric Lighting Order of the Board of Trade in reference to the use of the current for charging batteries not in connection at the time with house mains or lamps. It need hardly be said that in the employment of high tension electricity, special precaution is taken to carefully guard the wire and thoroughly insulate it. Having had the pleasure of visiting Earnock Colliery, on an invitation from Mr Gilchrist, the manager, and witnessing the installation of incandescent lamps in the pit he (Mr Beckingsale) was greatly interested in what he saw, and was struck with the advantage of the light for such purposes. If he might make a suggestion it would be, that the leads be periodically tested, to see that there was no loss of insulation and of current. He thought the time was not far off when all works of importance, especially those having steam-power, would find the introduction of the electric light a necessity.

The discussion was at this stage adjourned.

SPONTANEOUS COMBUSTION OF COAL IN SHIPS.

BY MR JOHN CONNAL.

My object in the reading of this paper is to endeavour to show the possibility of the prevention of spontaneous combustion of coal in ships.

I will confine my remarks to combustion in ships laden with Scotch coal. It will be necessary first to ascertain the sources of heat and the causes that lead up to spontaneous combustion. These may be, so far as we know, ultimately reduced to two in number—viz., chemical combination and mechanical force; the former of which will be the subject of our present consideration. It is a well-known fact that most coals, under certain conditions, will ignite spontaneously, such as, *e. g.*, coal

in large quantities in bin or on board ships, and which contains iron pyrites moistened with water. The pyrites which most readily give rise to spontaneous combustion are the proto-sulphides and bi-sulphides of iron. Sulphur of itself has no tendency to ignite spontaneously; but, in combination with the sulphurets of iron just specified, it will, when mixed with damp coal in bin or on board ship, as already stated, and well ventilated, give rise to spontaneous combustion. The mixture in decomposing generates heat from chemical combination, and, after the lapse of say 80 to 100 days, probably produces the result I have referred to. Spontaneous combustion of coal cargoes has not been much heard of except within the last fifteen years; and it is only during the last ten years of a personal experience extending over upwards of thirty years (in which time I have superintended the shipment of about 600,000 tons of coal for long foreign voyages), that I have been startled by the increasing number of disasters from this cause. We naturally look for the reason of this very serious change. The coal is of the very same class as shipped in former years; but, after investigation, we find that English ship-owners have for a long time past been in the habit, when loading ships with English coal, of causing an elaborate system of ventilation to be carried through their ships (as indicated by A and B on Fig. 1). This system is composed of a perforated ventilating

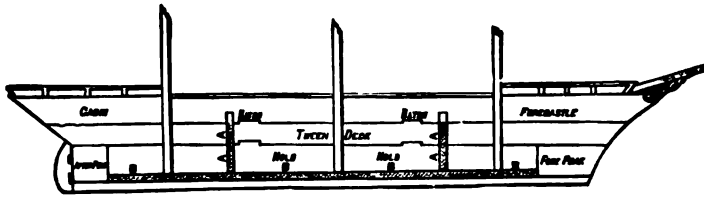

FIG. 1.—PRESENT METHOD OF VENTILATION.

tunnel along the keelson of the ship, with two or three ventilating shafts therefrom to the deck. The arrangement no doubt is necessary and right, when applied to ships loaded with certain kinds of English coal, to prevent explosion of carburetted hydrogen gas which the coal gives off; but this system of ventilation

should not be applied to vessels with cargoes of Scotch coal. However, strange as it may appear, the English process has, within the last ten or fifteen years, been carried out in ships laden with Scotch coal, and, in my opinion, is the source of all the disasters which have befallen such vessels. For Scotch ship-owners to adopt and apply it to their vessels, is simply to court destruction.

To avoid accidents in ships laden with our coal, I would entirely disapprove of ventilation. To illustrate the truth of this theory, I will give a few examples. If you put fuel into a common furnace and leave its doors wide open, the combustion will be slow, but partly shut the doors and let the air press up through the bars and the combustion will immediately become rapid; while if the dampers be put down so as to exclude the air entirely, the combustion ceases. Or, again, when a fire occurs in a mine, arising from whatever cause, efforts are made to confine it to the part where it first originated by building a strong air-tight barrier of bricks, but if this fail the mouth of the mine is hermetically sealed. The method of ventilation I would propose in regard to coal cargoes would be on the same principle, namely—Batten down the hatches air-tight, put down through the main hatch a six-inch perforated metal pipe (as marked B on Fig. 2), inserting it well into the cargo, and having

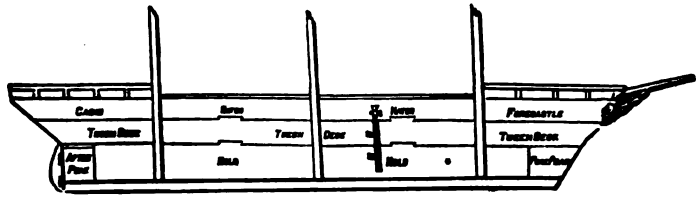

FIG. 2.—MR CONNAL'S METHOD OF VENTILATION.

a cock on deck which could be opened periodically to allow any vaporous accumulations to escape—as evaporation cools the body from which it issues,—while the pipe would also serve the purpose of allowing explosive gas to get free should any accumulate, although I do not entertain any fears on that head,

as I am not aware of a case where danger arose from that source in Scotch coal cargoes. The captain could also use this pipe for testing the heat of his cargo by inserting the thermometer into it should he consider it necessary. I may here mention that at a private inquiry into the loss of a ship, held by the Board of Trade seven or eight years ago, I expressed an opinion as to the course that should be adopted in the case of vessels laden with Scotch coal, which was almost in similar terms to that which I have here stated, and some months afterwards the captain of a ship about to load a cargo of coal showed me a printed document the contents of which embraced my recommendations. He got it from the owner of the ship, but where the owner got it I am unable to say.

How the unfortunate English mode of ventilation was introduced into Scotland I have not discovered. Possibly, Scotch shipowners considered that cargoes ventilated after this principle must be safe from any danger arising through combustion, and adopted the dangerous process; but, be that as it may, it is our duty now to shew the errors of the system by all means in our power, and have the erroneous practice discontinued, to be replaced by a more effective and safer method. Much prejudice and misapprehension exist regarding Scotch coal shipments, while disasters arising in connection therewith are much magnified by interested parties. For instance, a ship laden with a Scotch coal is lost at sea, and no one is left to tell the cause, which is put down to the cargo having taken fire, and the Board of Trade hold an inquiry, but no one is any the wiser, and the loss of the ship is a mystery. She might possibly have been burned through spontaneous combustion of her cargo, or have foundered; but all the same, her name and the class of coal she carried are posted up in the insurance companies' offices, where the loss is invariably attributed to spontaneous combustion. The oftener a certain class of coal is mentioned on the list, the higher the premium required to be paid for ships carrying it. This practice of the insurance companies of placing on their list all ships lost at sea without knowing definitely the causes that led to their loss, is an absurd one, and calls for immediate redress.

I might state, as an example, a case which came under my own

observation. A ship of 2000 tons burden was three-quarters loaded when a small quantity of smoke was seen to issue from the main hatchway. It was supposed that the cargo had taken fire. The smoke growing in volume, a number of men were set to discharge the coal, and after digging deep into it they found a quantity of oily waste smouldering. How, or by whom, it got there was never discovered; but, had that ship been sent to sea, and ultimately been lost through taking fire by this cause, as might probably have happened, the class and name of the coal which that vessel carried would have been put on the insurance companies' lists, and her loss, in all probability, attributed to the spontaneous combustion of her cargo.

A ship of 2500 tons burden, having on board 250 tons of coal, sailed in November, 1881, and was supposed to have foundered three or four days after leaving port, though no person could say definitely what became of her, as all hands perished; but the Board of Trade held an inquiry into the cause of her loss, and your respected ex-president was examined on the occasion. The case broke down, and justly so, as it was impossible that the loss of the vessel could have resulted from the spontaneous combustion of her cargo.

I have brought this subject before the members of this Institute in the hope that they may be able to throw more light upon it. In the interests of the coal trade it is our duty to do everything in our power to entirely remove the causes that lead to the spontaneous combustion of coal cargoes which for some time past has been the source of considerable harm to our trade. When we consider the importance of the coal trade of this country, and the great competition to be met in the immediate future; when we think of the vast coalfields opening up in America, India, China, New South Wales, and other places, it will at once become evident that we must take immediate steps to remove everything that tends to put us at a disadvantage. In fact, at this moment, as you are doubtless aware, a large fleet of steamers of heavy tonnage is being built for colliery companies to carry coal from some of the countries I have mentioned, to those very markets which are, and have been for a long time past, the backbone of our trade. It behoves us therefore to be on our guard for our

own protection, and to leave nothing undone that will maintain and strengthen that high position we have so long held in the coal markets of the world.

To settle the question which I have brought before you in this paper, will be one practical step towards that desirable end, and should we succeed, we will not only do our country honour, but earn for ourselves a reputation which will be upheld with pride by our posterity. You will deserve the lasting gratitude of the underwriters, cause a better demand for your coal for foreign shipments, and gain a higher price for it, as the shipper will not be handicapped as at present with a heavy insurance premium, while you may be the means of saving the lives of many brave sailors by finding a solution of the problem of spontaneous combustion.

THE MINING INSTITUTE OF SCOTLAND.

SPECIAL MEETING, 24th MAY, 1883,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

JAMES M'CREATH, Esq., President, in the Chair.

A recommendation by the Council to alter Rule III. of Section VIII. was agreed to. The rule, as altered, is as follows:—"Twelve copies of each paper printed by the Institute shall be presented to the author for private use, and such a further number given him at cost price, as may be approved of by the Council."

The office of a vice-president having become vacant through the appointment by the Council of Mr Barrowman as secretary, Mr David Anderson, Clydesdale Street, Hamilton, was elected for the office; and the ex-secretary (Mr James Gilchrist, Earnock Colliery, Hamilton), was appointed a Member of Council, in room of Mr Anderson.

GENERAL MEETING, 24th MAY, 1883,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

IMMEDIATELY AFTER THE SPECIAL MEETING.

JAMES M'CREATH, Esq., President, in the Chair.

Thirty-three members were present.

The Minutes of the Annual Meeting, held on the 12th April, were read and confirmed.

The following gentlemen were elected by ballot, and admitted as Ordinary Members:—

FREDERICK J. ROWAN, 134 St. Vincent Street, Glasgow.
ANDREW DUNSIRE, Cardenden, by Lochgelly.
ARCHIBALD BROWNLIE, Lassodie Colliery, Dunfermline.
ROBERT BROWN, Cadzow Colliery, Hamilton.
ROBERT WARDLAW, Burnbank, Hamilton.

Others were nominated for election at next meeting.

ERRATUM IN THE DISCUSSION ON "BLASTING GELATINE."

In Mr Drinnan's remarks at p. 18 the sentence commencing in the seventeenth line, "Not so said Nobel's people" &c., should be as follows:—So said Nobel's people; but Dr. Dupré in opposition to them, and also to Mr Begg, alleged that it was a physical mixture; indeed this argument was necessary, because, had he admitted chemical combination, he would have been compelled to admit that there could not be exudation until the original ingredients had again separated.

ON MR JAMIESON'S PAPER.

The PRESIDENT, after stating that Mr Jamieson was not present, invited discussion on his paper on "Electric Lighting," and none being offered, on his motion a hearty vote of thanks was accorded to the author, and the discussion was closed.

DISCUSSION OF MR CONNAL'S PAPER ON "SPONTANEOUS COMBUSTION OF COAL IN SHIPS."

The PRESIDENT, before the discussion opened, asked Mr Connal if he had any further remarks to offer.

Mr CONNAL said he wished it to be understood that it was Scotch coal-laden ships that were under discussion. His reason for saying so was that the two coals—English and Scotch—required different treatment; and he had a process applicable to English coal-laden ships for which he intended to take out a patent, or hand to somebody else to do so, and he wanted to say nothing about that unless he was pressed.

The SECRETARY read the following communication from Mr ROBERT STEVENSON:—

"When Mr Connal draws a distinction between English and Scotch coals, by saying that ventilation is in the one case 'necessary and right,' and in the other altogether wrong, persons not conversant with the coals may think that an ambiguous statement. I take it that the Scotch coals principally referred to are the Fife coals, which, for shipping purposes, are the most important, I have no doubt, in Scotland; and the English coals are very likely to be those of South Wales, and the anthracite and semi-anthracite coals of the Durham coalfields. The Fife coals, as a rule, contain little or no light carburetted hydrogen gas in an unstable condition within the texture of the coal. The English coals above mentioned are, on the other hand, highly charged with that gas, which is given off in large quantities in the presence of a warm and moist atmosphere. (See Mr Lindsay Wood's valuable paper "The Pressure of Gas in Solid Coal," Transactions of the North of England Institute,

Vol. xxx., Pt. iv.) Hence the necessity for ventilation to keep the cargo cool, and free from explosive gas. Mr Connal is therefore right in saying that ventilation is necessary to prevent explosion; but the question raised in his paper is whether it is also necessary to prevent spontaneous combustion? Now, according to Mr Connal's experience, there have been more ships lost with Scotch coal since the system of ventilation was adopted than before; and, consequently, he draws the conclusion that it is due to ventilation. There are two things which ventilation does or ought to do:—First, If a cargo be properly ventilated there ought to be a constant current of pure air moving through all the crevices or interstices thereof; secondly, This current of air should keep the cargo much cooler than if there were no ventilation. To generate spontaneous combustion in Fife coal is very difficult, and requires a combination of causes. It requires a certain temperature combined with moisture; and fine coal mixed with a certain kind of pyrites or sulphury stone, which is generally found immediately under the coal, and is only filled with the coal through carelessness; it is oftener mixed with the small coal. It is a very rare occurrence for a bin of round coal to take fire spontaneously; nor will a bin of small coal take fire if it is laid on a cool and dry hearth; but, if it be laid on a damp or warm hearth, it will begin to smoke in a few days, and the fine daugh is the first to heat. I am therefore of opinion that, with a cargo of clean Fife coal, in pieces of moderate size, it is immaterial whether it be ventilated or not, so far as the cargo is concerned; but, if the coal is mixed with daugh and fine coal, it will tend to heat quicker if it is not ventilated; but if the hatches are kept close as Mr Connal proposes, it will not take fire, and the heat may not spread further than a few feet during the whole voyage. On the other hand, if it is ventilated it might not heat during the voyage, but if it does heat it would very shortly take fire, and nothing could save the ship. Taking everything into consideration, I join with Mr Connal in thinking that the evil effects of spontaneous combustion may be neutralized by excluding the air from the cargo; but, to be safe, it requires to be hermetically sealed, and the thermometers should be inserted in small iron tubes, closed at the lower end, and air tight where they enter the hold. I would add that every hold should be thoroughly swept out, and whitewashed with a good coat of chloride of lime, and that the bottom of the hold should be laid with one or two rows of kiln-dried deal planks, or any suitable absorber of moisture, before the ship is loaded; and, above all, that the coal shipped should be in a clean and lumpy condition. I have no doubt but with these precautions, the evil effect of spontaneous combustion in coal cargoes would be got rid of to a great extent."

The following communication from Mr THOMAS ROWAN, who is not a member, was also, with permission of the meeting, read by the Secretary :—

My attention having been directed to the paper read by Mr Connal at the last meeting of the Institute, I desire, if by the indulgence of the members of the Institute I am permitted, to offer a few observations on that paper, and generally on the subject of which it treats. My apology for thus trespassing on the attention of the members must be the great interest I take in the subject under discussion. Mr Connal starts with the statement that "the sources of heat and the causes that lead up to spontaneous combustion may be reduced to two in number," viz., chemical combination and mechanical force. To the former of these spontaneous cambustion is undoubtedly due, but with reference to the latter, I cannot comprehend how mechanical force can contribute in any way whatever to the spontaneous ignition of coal. Indeed, it is manifest that Mr Connal confounds the action resulting in spontaneous ignition with the cause which gives rise to explosion of gas in coal. They are distinct and separate actions, proceeding from distinct and separate causes. Explosion is entirely consequent on the liberation from the cells and pores of coal of that gas already existing in them, viz., marsh gas, or the fire-damp of mines. And it is to this gas, evolved during the process of the formation of the coal itself, when mixed with a sufficient volume of air, and on the application of a sufficiently high temperature (such as the flame of a lamp, etc.,) that accidents on board coal ships from explosion is due. Mechanical force can contribute to explosion in as far as it may cause the disintegration of the coal, and by crushing and splitting up the cells, thus set free the fire-damp enclosed in them. Spontaneous combustion is entirely due to the heat developed by chemical action. This chemical action has been attributed to different causes, some of which, however, are but hypothetical; but it has been demonstrated that the oxidation of the sulphides existing more or less in all coal, as well as the oxidation of the organic matter of coal, can give rise, under certain conditions, to what has been termed the spontaneous combustion of coal. But apart from the origin of this chemical action, there are certain facts connected with the occurrence of spontaneous combustion of coal in cargoes which very clearly indicate to us the direction which must be taken when dealing with coal before it can be regarded otherwise than as a dangerous and treacherous cargo. It is to these leading facts I shall now briefly allude before discussing Mr Connal's proposed plan. First—Spontaneous combustion always *commences at some spot* in the cargo, but, as regards locality, this spot is vagrant, and is found sometimes near the keelson, at other times

near the surface. From this starting point, wherever it may happen to be, the action spreads. Secondly—Spontaneous combustion is always a *slow action* in its *initial or incipient* stages, but as it proceeds, the accumulating heat causes it to progress in an accelerating ratio until temperatures requisite for the ignition of the coal are reached. The high temperatures produced often as well determine the destructive distillation of the coal, evolving thus, hydro-carbon products of a highly inflammable and explosive character. From carefully prepared statistics —by Mr R. Cooper Rundell, the most efficient secretary to the Glasgow Association of Underwriters—which are published in the Royal Commissioners' Report of 1876, it is found that *sixty days* after leaving port is the average time before combustion takes place. No fires have occurred before the 37th day, and one case is recorded of 190 days elapsing before combustion was observed. Thirdly—As might be anticipated from these facts, it is also found that the cases of spontaneous combustion of cargoes increase *pari passu* with their tonnage—the larger the cargo the greater the liability to spontaneous combustion. While cargoes of 500 tons and under have shown an average of casualties under ¼ per cent., those cargoes over 2000 tons show an average of nine per cent. It is evident from a study of these facts, that the heat first set up by chemical action requires *time to accumulate* and *bulk* to be *retained* before temperatures of inflammability can be reached. These are the cardinal facts which demand scrupulous attention in any attempt to deal with coal in cargoes in relation to spontaneous combustion. There is no doubt that if coal cargoes *could* be thoroughly ventilated, the action of the spontaneous combustion could never progress to any appreciable extent, as any accumulation of heat could not take place; but the mechanical conditions of coal closely packed in a cargo render it impossible for air to pass through it, or indeed for any ventilation to take place except in the immediate vicinity of the so-called ventilating shafts. Different methods of packing coal in holds have been advocated with a view of rendering "through ventilation" possible, some of the plans involving the separate arrangement of nearly each individual lump of coal in the cargo. Now all such methods are practically useless, for by attrition of the coal in the holds, through the movement of the vessel, a cargo, however "scientifically packed," must finally assume the same condition of "densely packed." Imperfect ventilation (as Mr Connal rightly indicates) is dangerous, for it can only serve to supply an element for the oxidation that progresses, and consequently we find that the great majority of cases of ignition have occurred in cargoes where so-called "through" ventilation has been attempted. But, unfortunately, it is also found that doing without any

ventilation whatever, offers no immunity from the occurrence of spontaneous combustion, and that, whilst all attempts at ventilation have had the effect of increasing the *liability* of a cargo to spontaneous ignition, that action has taken place in cargoes where ventilation has never been attempted, in summer or winter, however loaded, and (as Mr Rundell has shown) with "most, if not all the different varieties of coal usually exported from this country." With regard to the plan proposed by Mr Connal for treating coal cargoes, if we apply it to the test of those facts I have so imperfectly and briefly touched on, I am afraid it must be seen that his method of treatment is quite inadequate, and would be useless either to prevent or arrest the action of spontaneous combustion in a cargo. It must be perfectly clear that merely inserting in a coal cargo *a six-inch* pipe, with a cock or similar appliance, to be opened periodically, can never prevent chemical action from arising, and it must also be patent that the same mechanical conditions and obstructions that render ventilation in a cargo impossible must also prevent those "vaporous accumulations," referred to by Mr Connal, from finding their way unaided to the interior of this pipe, except from a most limited area round about it. When chemical action is once set up in a cargo, it must be dealt with by much more efficient and energetic measures than those proposed by Mr Connal, if the *ultimate results* of that action are to be prevented. The plan I have already proposed for dealing with coal cargoes, is by placing a series of small iron tubes throughout the coal holds, and at different levels amongst the coal—thus sub-dividing the cargo into sections. Those tubes are fitted with abstractors, which are brought into play when chemical action is detected in any part of the cargo. In this way the heated products of incipient combustion could be drawn off from the *locality of their production*, and be thus prevented from lodging in the body of the coal and accelerating the action from which it proceeded, or from exciting similar action in other parts of the cargo. By these means heat would not be retained or accumulated, and the temperatures requisite for inflammability would not be reached. The starting of chemical action can be detected by placing in the tubes either ordinary or electrical thermometers. When the latter are used, by proper connections to, say, the engineer's cabin, and with an indicator there, the very moment when chemical action takes place, energetic enough to cause any appreciable rise of temperature, can be ascertained, as well as the locality in the cargo where this action has its start. As I have already remarked on another occasion with reference to this plan, 'with the means of thus ascertaining from different parts of the cargo what was taking place, the captain of the ship would have

ample time to prevent the action resulting in any serious catastrophe. Under any circumstances, the *loss of the vessel* could always be prevented, and probably the saving of all but an inconsiderable portion of the coal. In conclusion, I must state that while I believe chemical action may thus be controlled within harmless limits, I am also persuaded that the only *thorough* preventive to its arising *at all*, is by a special treatment of the coal itself prior to its shipment. I have already proposed a plan of arriving at this, but it would be out of place on this occasion, to do more than make this passing observation. With Mr Connal's remarks on the great importance of this subject to this country, we must all fully concur. I am sure the end he desires—viz., the safe conveyance of coal on board ship—can only be arrived at by the scientific and practical appreciation of methods, indicated to us by an intelligent analysis, and apprehension of the various phenomena attending the action of spontaneous combustion in its starting, progress, and final (too often) disastrous results.

Mr SMART—This is a very important subject Mr Connal has brought before us. The causes and effects of spontaneous combustion of coal cargoes on board ships have engaged the attention of many eminent scientific men in this country. A Royal Commission was appointed in 1875 to inquire into and report on this subject, and the report, which was a very exhaustive one, was issued in 1876. The conclusion arrived at as to the cause is embraced in the second article of their summary, and is as follows:—"That the breakage of coal in its transport from the pits to the ship's hold, the shipment of pyritic coal in a wet condition, and, especially, ventilation through the body of coal cargoes conduce to spontaneous combustion, even though the coal may not be unfit for conveyance on long voyages." Mr Connal, in his paper, advocates the same view and condemns ventilation. My impression is, that considerable dubiety hangs over the causes of this so-called spontaneous combustion, as we find it has taken place on board what were said to be well ventilated ships and partially ventilated ships, and ships that had no ventilation at all; with coal that was shipped dry and with coal that was shipped wet; with coal that was known to contain a large percentage of pyrites and coal that was known to have none; under all these conditions vessels have been lost through the spontaneous combustion of coal cargoes. It seems strange that the cargo of one ship should

ignite while dozens of others loaded with the same coal and in the same apparent condition arrive at their destination safely. It is generally allowed that iron pyrites is the primary cause. This can scarcely hold true in all cases, as a great many vessels from Scotland, whose cargoes have been reported to have taken fire, were loaded with Splint coal, in which there is very little, if any, pyrites. This, naturally, leads one to think that there must be some other active agent that, under the same conditions of heat and moisture, generates spontaneous combustion. My impression is that coaly blaes or some other bituminous rubbish which may be mixed with the coal is the cause. At many collieries we find large bins of coal in which there is a considerable percentage of pyrites, and it is very rarely that we hear of any of those bins of coal taking fire. On the other hand, the dross which is produced from the Main and Splint seams of coal, and which contains a very large percentage of blaes and other foreign matter mixed up with it, and is what may be termed dirty, very frequently takes fire, and certainly this fire does not originate for want of surface ventilation, as the surface is exposed to every wind that blows. I am, therefore, inclined to believe that pyrites is not the sole cause of spontaneous combustion, but that we may attribute the cause of many of those fires to some other carbonaceous matter. Merchants arranging for a cargo of coal seldom consider the probability of the cargo taking fire, their principal aim being to get it as cheap as they possibly can ; and it is a notorious fact that our lowest quality of coal is generally shipped, coal which in the process of working has a considerable quantity of rubbish produced with it, and which the seller cannot afford to clean because of the low price at which he has to furnish it. This rubbish is naturally amongst the small coal in the centre of the hold, immediately under the hatch where all the fires from spontaneous combustion originate, and I am of opinion that were the coal of all cargoes as carefully cleaned as that which goes to the home market there would be fewer vessels burned. Mr Connal advocates no ventilation as a preventive to spontaneous combustion. In my opinion, this is against the laws which regulate our system of working. We are taught "That an adequate amount of ventilation shall be constantly produced to dilute and render harmless

noxious gases in every mine." May I ask why this should not apply to every ship's cargo that is liable to be effected by the generating of dangerous gases? No doubt a large proportion of the evidence laid before the Royal Commisson, as well as the opinion expressed by such able men as Professor Abel and Dr. Percy, has been against ventilation of coal cargoes. My opinion is that the danger is caused by such ventilation not being thorough. The present method is not a proper one, but one that has a tendency to feed a fire should such be caused by spontaneous combustion. There are generally in every well fitted-out ship two ventilators from the deck to the keelson, which are necessary in order to keep some cargoes of merchandise sweet. These are generally of iron or wood, box shaped and perforated with holes, and in many cases go from top to bottom only, and are principally for an exit to the heated atmosphere of the hold. In other cases there is a space left covered on each side of the keelson which forms a passage between the fore and aft ventilators, and in this way upcast and downcast shafts are formed to the floor of the ship. You must understand that these are perforated all the way down, and the fresh air passes through the cargo from the downcast and ascends by the upcast to the surface. The fresh air could never force its way through the centre of the holds under the hatch of a coal cargo, which is generally the seat of the fire. Air circulated in this way, in my opinion, would only reach the fringe of where the fire originated, and supply sufficient air to aid the combustion. I understand that in almost every case the fire originates in the holds immediately under one or other of the hatches where all the small coal and rubbish are situated; and from our system of loading direct from trucks, the contents of of which (about six tons) are hurled down, the round coal spreads to the wings of the ship and the spaces fore and aft of the hatch; thus leaving all the small coal of the cargo pounded down to a solid mass, through which no air could permeate, thereby forming the most favourable conditions required for aiding spontaneous conbustion. Should the cargo in transit become wet, the finely divided particles retain the moisture, and the smaller the coal the more surface is exposed to the decomposing element, and with the natural heat generated in a ship's hold, aided by the

heat of a tropical climate, spontaneous combustion is produced. The Royal Commission strongly recommends surface ventilation by the insertion of pipes through the deck of the ship, but not carried down to or through the coal, so as to form upcast and downcast shafts. This system is expected to ventilate only the surface of the cargo. In my opinion, this is a sort of an anomaly, as, should there be any heat generating in the cargo, the fresh air would be sure to find it out, because a fire naturally draws air towards it. From the construction of a ship, with her hollow iron masts generally perforated, from the effects of her being tossed on the billows of the ocean, and through the action of the motive power to drive her onward, currents of fresh air are being circulated through the hold which cause a constant ventilation. Could you make a ship's hold perfectly tight, or cause it to be hermetically sealed so as no fresh air could be admitted, then we would have no spontaneous combustion in coal cargoes; but as this is not practicable, I would suggest that a thorough ventilation be adopted, having regular upcast and downcast shafts with air conductors running fore and aft, connected therewith at such distances as may be considered necessary through the hold of the ship, more especially under each hatch. These to be made of malleable iron, say six to nine inches square inside, the top and bottom plates to over-lap the sides by about 1½ inch to protect the air passages, the sides either to be perforated or constructed in the form of a venetian blind. During the process of loading, the coal in the hold would require to be levelled so that a bed would be formed for the boxes at such distances as the air passing and percolating through the coal would be able to keep the cargo thoroughly cool. The ends of the boxes would be inserted into the upcast and downcast shafts. By the adoption of this system the hatches would never require to be disturbed. Should a greater quantity of air be required or a greater velocity be considered necessary than what is usually created by natural ventilation with the ordinary cowls, an exhausting fan could be erected over the upcast. In a sailing vessel this fan could be driven by a wind-mill, and in a steamer power might be obtained to do the necessary work. By this method a thorough ventilation could be got through all parts of the cargo at a very trifling cost, and a

stop would be put to the spontaneous combustion of coal cargoes. Could a ship's hold be hermetically sealed there would be little fear of the loss of a ship in the course of the voyage, but I do not think it would prevent the chemical action from taking place and the generating of a considerable amount of heat that would fly into active combustion as soon as fresh air was admitted. I cannot see that the insertion of a pipe into the cargo would be of any practical use, as, from the condition Mr Connal would expect the cargo to be in, no gas would attain a pressure that would be forced through a pipe unless fresh air was admitted to the hold. From Mr Rowan's remarks I cannot see the practical adaptability of the system he proposes to prevent combustion. He purposes "placing a series of small iron tubes throughout the coal holds at different levels amongst the coal, thus sub-dividing the cargo into sections." He also states, "these tubes would be fitted with abstractors to draw off the heated products of incipient combustion." It would be necessary to have the size of the tubes stated and the method of distributing them, as well as in what form the abstractors are to work, as I fail to understand what force could extract the heated gases from a compact cargo of coal. I hope to have some explanation from Mr Rowan on the subject before this discussion closes.

Mr F. J. ROWAN did not think that he could add any explanation to the remarks his brother had sent, because he was not acquainted with the details of the abstractors recommended; but he understood from some of the papers he had seen that, where convenient, a jet of gas was used to heat the air in order to cause an upward current through the abstractors, and in other cases some mechanical device, such as a fan, was used, where heat was not available. The main idea, however, was to cause a draught by some artificial means, and not to trust to natural action, in order to force a current of air through those ventilators and through the coal cargo. Now, it seemed to him, from what he had heard since he came into the room, that there was some little haziness on that point, because he had heard plans proposed on the model of the ventilation of a mine. But it seemed to him the conditions were not at all similar. In a mine, they wanted to confine the current to certain

well-defined channels; but in a coal cargo they wanted to get the air as much as possible diffused throughout the mass. That was extremely difficult, from the fact that the coal was very closely packed together, and the very method of loading it caused the formation of a large quantity of small coal which made it extremely difficult to get air to pass through, and yet that was where the air was wanted. They wanted the coal all equally, and not merely certain portions, ventilated, and therefore they must subdivide the cargo as much as possible, as the air would only permeate to a short distance from each of the pipes and shafts that were introduced.

As to the causes of spontaneous combustion, he believed it had been very clearly proved that the most dangerous coals were not those containing sulphur or pyrites. Where they had coal exposed to the atmosphere, and moisture to a much greater extent than was generally found in coal cargoes, the decomposition of the sulphide of iron did proceed, but moisture was indispensable. If they had coal containing ever so much sulphur exposed merely to dry air, the decomposition of sulphur would proceed so slowly that no appreciable heat would be created, but where there was a large amount of moisture and free action of the air, the conditions were quite different. But the main point of danger was in the oxidation of the carbon, and it was a well-known fact that the finer the particles of carbon were the more rapid was oxidation. In fact, he had seen fire caused in drying stoves by rapid oxidation of carbonaceous matter in a very fine state of division, where there was no appreciable heat—simply a current of air, to which the carbonaceous matter was exposed. The illustration Mr Smart referred to of bins of dross taking fire frequently in the open air was strictly in point. He did not believe the combustion was due to the presence of blaes or such matter, although the hydro-carbons in them would add to combustion when once it had commenced; but the small dust was capable of so rapid oxidation that the evolution of heat was sufficient to start the combustion in the mass of coal. That he believed to be the grand cause of danger; and it seemed the only rational way of preventing disaster was to prevent the temperature rising to the point of danger, and that could only be done by taking such means

as might be found practicable and efficient to introduce through the mass of the coal, not through the pipes merely, sufficient air to carry this out.

Mr J. H. RONALDSON said reference had been made to certain hypothetical opinions as to how the heat in coal cargoes is caused by pyrites, and it might not be amiss to mention one opinion entertained by some chemists, viz., In the decomposition of the iron pyrites in the presence of moisture, sulphuric acid was formed, and that in its turn acted on the remaining iron pyrites, thus causing heat. He did not know if that were a point which had been brought forward yet.

Mr DRINNAN—In addition to that, I think it would be well to say, when it reaches a certain degree of heat, it will burst into flame.

The PRESIDENT said he was glad to see that the spontaneous combustion of pyrites seemed to be so well understood among the members. A considerable time ago, he had charge of a chemical work where alum and copperas were made from pyrites. Part of the process of making alum and also of making copperas was to produce spontaneous combustion of pyrites, but to keep it from igniting. When the alum ore was taken out of the pit, it was put in large bins, and no spontaneous combustion of any moment occurred until it was well watered. After being watered for two or three weeks, it was allowed to remain for a number of weeks more, and then spontaneous combustion set in. The temperature was tried in a very rough way by putting a poker into the bin, allowing it to remain for a time, and drawing it out, and feeling if it was hot. Sometimes the combustion was allowed to go too far, and ignition took place. The ignition took place first always about 3 or 4 feet from the top, as well as he could recollect, and 3 or 4 feet in from the side of the bin. It appeared to require a certain amount of air to produce combustion, but not enough to cool it. It also required a certain amount of water or damp to produce combustion, and also not enough to cool it. When they got the bin hot enough, as they considered, they then began to water it and take away the sulphate of alumina. This went on for some months, and by and by the bin got cooled and spontaneous combustion would go on no longer. It was then put into heaps and set fire

to, and the remaining pyrites converted into sulphate of alumina and iron. He might mention, when a bin took fire, throwing water on it would not put out the fire. There was a crust formed which prevented the water from flowing through, and whenever they stopped watering it the fire broke out again. The fire was put out by boring a hole with a poker down and pouring water down until the ore got cooled again. He saw, in the report of the Royal Commissioners, that, in endeavouring to put out the fire in one at least of the coal cargoes, they found the water would not penetrate into the coal. If they had put poker holes into the mass, they might have got the water down and had a better chance of putting out the fire. What was mentioned last about the pyrites being partly converted into sulphate of iron and partly into sulphuric acid was quite correct. In the manufacture of copperas, iron requires to be added to take up this additional sulphuric acid; but the fact of its being formed was quite sufficient to account for the heat necessary to cause ignition of coal or any combustible substance, or even pyrites itself. There appeared to be some little difference of opinion with the gentlemen who had spoken as to whether the oxidation of blaes or the oxidation of small coal could produce spontaneous combustion. He might say that he had seen no fire underground, originating from spontaneous combustion, which could not be accounted for by the presence of visible pyrites in the coal or in the material which took fire, excepting fires that had taken place from steam getting in contact with the blaes which formed the roof of the Splint coal. In going through the Splint coal wastes where these last spontaneous fires took place, he could not notice any efflorescence of either sulphate of alumina or sulphate of iron; but there was an efflorescence from the blaes of some other substance, what it was he could not tell. If any gentlemen present who were in the habit of going through such wastes could throw further light on the matter, perhaps they would be good enough to do so.

Mr DRINNAN, while he was not prepared to subscribe to some of the views that were stated, agreed with all the members who had preceded him as to the importance of the paper and the possible good that might result from the discussion upon it. He had intended calling attention to the causes that were

said to have caused spontaneous combustion, but these had already been taken up by Mr Rowan. On p. 24, near the top, Mr Connal said—"Sulphur of itself had no tendency to ignite spontaneously." He (Mr Drinnan) could not agree with him in this, as it was a well-known fact that sulphur was very inflammable and would ignite at a temperature of 240°. In the line following he stated—"In combination with the sulphurets" (reads). He thought there was something of a *lapsus pennae* here, because, on reading this, one was led to infer that it was due to sulphurets of iron in combination with sulphur, whereas, he thought, Mr Connal meant to say "the sulphurets of iron just specified will when mixed with damp coal," &c., &c.

The PRESIDENT—I think it is quite evident that it is the sulphur in combination with iron that is meant.

Mr DRINNAN—Just so, but it would have been more clear to have said so than to speak of "sulphurets of iron with sulphur in combination."

Mr CONNAL—They are both the same thing.

Mr DRINNAN (continuing) said he entirely disagreed with the statement that a coal cargo when well ventilated gave rise to spontaneous combustion, and he entirely concurred with Mr Smart and for very much the same reasons. He could not help thinking that Mr Connal had not been at all apt in his illustrations for the purpose of proving that ventilation was a bad thing. At p. 25 he says—"To illustrate" (reads). Well, he thought they would observe he was dealing here with an entirely different state of things from what existed in a ship's hold. He was dealing with a condition of things where a fire was in existence, and in the ship's hold the condition was that there was no fire and the object of ventilation would be to prevent any fire originating. But even if they agreed with the statement that Mr Connal made there, it would be found on looking closely to his argument, that he proved the opposite of what he intended. He said—"If you put fuel into a common furnace" (reads). The whole object was to show that ventilation was a bad thing, but he added—"If you open the doors (reads). In this way Mr Connal proved that combustion was more rapid with a small quantity of air, than with a large quantity; while his object seemed to be to prove the opposite.

He thought, too, what he said near the bottom of the page—that evaporation cooled the body, &c.—contained a doctrine he could not subscribe to in its entirety; but, granting that the statement was true, was it not desirable to have good ventilation that the evaporation might be as thorough as possible? Before sitting down, he would like to be sure if he was at one with Mr Smart in his idea in respect to the ventilation of the hold. He thought, like him, there should be a downcast and an upcast just similar to what they had at their pits, but the way in which he would be inclined to do it would be to make the downcast shaft perfectly close down to the tube that would run along the bottom of the hold, having it all perforated, and the upcast shaft or tubes perforated up to the line of the hatchway, so that any vapour that might be underneath would have an opportunity of escaping in the upcast, but he would carry the downcast down to the bottom of the hold before allowing the air to escape. He thought if ventilated in that way, and more especially if a small ventilating fan were applied, there would be very little danger of spontaneous combustion occurring in coal cargoes on board ships.

Mr SMART said there were several details which would require to be worked out according to the method he had explained, and one of these which had suggested itself to his mind related to the heating, viz., that one, or both, of these ventilators, or rather shafts, should be so large that a man could go up and down and use it as a means of communication to the bottom of the hold. By this means the temperature of the cargo might be tested at the connection of the different air passages; and, should it be found that any considerable heat was generating at any one of these passages, the inlet to the others could be closed, and the whole air be forced to travel through the heated portion, thereby cooling the part of the cargo that was likely to go into combustion.

Regarding the encrusted matter mentioned by the President which water would not penetrate, he asked, had the heap been scattered would it have gone out when cooled by the air.

The PRESIDENT answered in the affirmative.

Mr SMART said, in similar fires he had seen, they might play the hose on it ever so long, the water had no effect; but when air got through it, it went out.

The PRESIDENT—In putting out fires underground, the best way is, if you can manage it, to shovel the thing out and let it cool; but in this case the most convenient way of putting out a fire in the heap of ore was to pour water through it.

Mr DRINNAN presumed the discussion would be continued for another evening, but he thought it would be well to have the opinions of as many members as possible before them at next meeting. Mr Prentice and he had been exchanging opinions on the subject, and he (Mr Prentice) had given what he considered a reason which he (Mr Drinnan) thought it would be well that the Institute should hear.

Mr PRENTICE said he had been struck with the remarkable coincidence in the time which Mr Connal mentioned as the period during which fires in coal cargoes had increased and the opening up of the fiery seams around Hamilton and Motherwell. He asked Mr Connal if he did not think that perhaps the opening up of the fiery seams in the Clyde basin was the cause of those disasters. The coal being raised in the neighbourhood of Hamilton and Motherwell was as likely to give off gas as any of the English coals, and it was only from the time of the opening of those coal fields that Mr Connal had noticed a great increase in the burning of ships.

Mr CONNAL said, as this discussion would likely come up again, he could not go over Mr Rowan's paper that night. It was long and elaborate. He certainly disagreed with him, but there might be some points, in looking over it, that he would bring up. With regard to Mr Stevenson's views, as they agreed with his, he had nothing to say. In reference to Mr Smart's remarks, he did not at all believe in his theory about the coaly blaes or other rubbish. There could be no spontaneous combustion without iron pyrites. He had raised a very important question regarding the hermetically sealing of the hold of a ship. He confessed it could not be done in some wooden ships. It was almost impossible to make them tight, but iron ships carrying coal cargoes from 1000 to 2000 tons, could be hermetically sealed. Mr Smart talked of a ship tossing on the waves; that was perfectly true. At the same time, air could be kept perfectly well from getting into her cargo. They would imagine that in a large

ship with three masts and a large stretch of sail the straining of the masts would let in air at the deck. Well, that could not be; because there was a wise provision made for that in the shape of a "coat" put round the mast and nailed to the deck. That was where the danger would be, but with the "coat" on there was none there at all. He, of course, disagreed also with Mr Smart's ideas of ventilation, as he went in for none at all. With reference to Mr Drinnan's criticisms, the speaker read as follows from the examination of A. P. Vassard before the Royal Commissioners:—

"When iron pyrites is left when wet to the action of the air, or to the action of a moist atmosphere, it gradually undergoes a chemical change; one part of the sulphur is oxidised partly by the oxygen of air and partly by that of the decomposing water, and becomes sulphuric acid. Thereby the other part of the sulphur is disengaged from the pyrites, and also hydrogen from the water. This sulphur and the then free hydrogen are thus thrown in presence of each other combine and form hydro-sulphuric acid or sulphuretted hydrogen."

He thought that would meet what Mr Drinnan had said. As to the sulphurets, the sulphides and sulphurets were the same thing, and he should have kept to the one term. Referring to Mr Prentice's question, he did not think the gases coming off the coals had anything to do with spontaneous combustion in coal cargoes. The increase of these fires was entirely owing to the mode of ventilation that was now adopted. At the time he spoke of there was no ventilation in Scotland, and he had been sorry when he got instructions from an English owner to see that the ventilation was thoroughly carried out. Since he prepared the paper, he had seen a good many captains who had loaded coals. He had examined them thoroughly, and not one who went to sea without ventilation had had any disaster, and from the report of the Royal Commissioners he found not one ship that had been burned but had had ventilation. There was not one without ventilation that had been burned. ("No.") He was perfectly satisfied that the only ships that had been burned where they had not had ventilation were those that had off their hatches, and he said they ought not to have had them off.

Mr PRENTICE said Mr Connal stated at the bottom of page 24 —"The arrangement" (reads). It seemed Mr Connal thought

ventilation was necessary when the coal gave off carburetted hydrogen gas. He submitted that within the last ten years the principal coal cargoes were from pits that gave off large quantities of carburetted hydrogen gas, and that previous to this there was not nearly so much coal shipped that was of this quality.

Mr SMART, regarding what Mr Prentice stated as to the increase of these fires, said he found that from Scotch ports in the first nine months of 1873, 89 vessels sailed with coal which crossed the equator, of these 3, or 3·37 per cent., took fire. In the corresponding period of 1874 there were 97 vessels loaded, of these 9 took fire, or 9·28 per cent. Mr R. C. Rundell, in the evidence he gave before the Royal Commission, stated that after the passing of the Coal Mines Regulation Act (which restricted the employment of children who had previously been engaged picking the coal), many of the boys' services had been dispensed with, and the coal was not so well cleaned. He also stated that in 1874 the excessive demand had been met by the working of a large quantity of inferior coal, which met with a ready market. This may possibly account for the large increase of ships burned that year. It had been shown that the number of ships lost had increased since that time, but the quantity of coal shipped had also increased. He (Mr Smart) did not think there was the same average quantity of ships burned, but more coal was carried by steamers, and they took less time on a voyage, and consequently there was not the same time to produce spontaneous combustion and the loss of the ship.

The PRESIDENT said in reading the report of the Royal Commissioners he was sorry to observe that in it the composition of the coals shipped from two collieries in the immediate neighbourhood was given so that 12 per cent. of it was said to be iron pyrites. Now, there were no Scotch coals shipped that contained such a percentage of pyrites, and it was a pity it should not be contradicted. It was said, no doubt, in that analysis that it was possible the bulk of the coal might not contain so much sulphur as this sample; but he thought it was quite evident that the sample was a picked piece. That analysis was reproduced in a little book of Mr Thomas Rowan's which he had presented to the Institute.

Mr CONNAL said he thought that must have been a great mis-

take, because no coal of that quality was shipped, especially from this district. The largest he could find was in England—3 per cent. In regard to what had fallen from Mr Drinnan, he was of opinion that a system similar to that being introduced for the preservation of green fodder—called ensilage—was what would keep coal cargoes safe.

FRENCH VIEWS OF ENGLISH MINING.

A Review of MM. Pernolet and Aguillon's Report on English Fiery Mines.

By Mr ROB. THOS. MOORE, C.E., B.Sc.

About two years ago, two French engineers, MM. Pernolet and Aguillon, visited this country as Commissioners from the French Government to examine the state of mining in England, and especially English mining legislation. They examined a number of collieries in England and Wales and were in Scotland. They were very industrious and very observant. The result is a large volume, copiously illustrated, in which they have given their opinions very freely upon the various points which came under their notice.

It appeared to me that it would be interesting to the Institute to have a review of this book, which is a companion to that on Germany, which was reviewed by Mr J. H. Ronaldson in Vol. IV., Part 6; and to that on Belgium, reviewed by me in Vol. III., Part 9. I have quoted largely where it appeared to me to be of interest, and have given their opinions pretty freely.

LEGISLATION.

All English mining legislation is summed up in the law of 1872. This may be divided into two parts: (1) That relating to the paying of workmen, hours of work, employment of women and children, &c.; and (2) That relating to the security of the workmen. It is to this second head that the committee specially draw attention.

In England, laws are generally made after an expression of public opinion, and there are always many discussions and meetings whenever an accident involving a large loss of life takes place.

Public attention was first called to explosions of fire-damp after the Felling explosion in 1812, where ninety-two persons were killed. This led to the foundation of an association at Sunderland to investigate the causes of explosions; and Sir Humphry Davy, while in the north on a visit to this association, in 1815, invented the safety lamp. Notwithstanding this, there was still an increase in the number of accidents; and Buddle in 1829-30, before a select committee, said this was owing to pillar working being carried on to a larger extent than was practicable before its invention. A select committee in 1835 had no suggestions to make, but some of its witnesses condemned inspection by Government.

An explosion at St. Hilda, South Shields, gave rise to the South Shields Commission, which gave a report in 1842 recommending inspection of mines as of railways.

In 1840 Lord Shaftesbury, who took a great interest in working men, got Government to appoint a Royal Commission, which shewed the condition of the miners to be very bad. After considerable discussion a law was passed preventing the employment of women in mines, and children under ten for more than eight hours a day, and preventing the payment of wages in public houses. An inspector was appointed to see the regulations carried out, but was not allowed to go down the pits.

The law of 1842 was looked upon with mistrust by the coal-master and indifference by the miner. Several accidents took place in 1844, and Mr Tremenheere, the inspector, gave in his first report, in which he said that the Scotch collieries were in a bad state. Petitions were sent in from Newcastle, and Lyell and Faraday were appointed by Government to inquire into the matter. The chief recommendation in their report was a separate ventilation for old workings. This was criticised strongly, and Sir H. de la Beche and Lyon Playfair were appointed to inquire into fiery mines.

In 1846 they gave a report recommending further inspection of the mines. This was followed by petitions by the workmen in favour

of it; and in 1849 there was a select committee of the House of Lords, and in 1850 a report by Messrs Blackwell and Philips on the subject. These inquiries gave rise to the law of 1850, which gave a more complete inspection of mines. Four inspectors were appointed, who were entitled to visit the mines underground, and if they thought any practice dangerous were to call the owner's attention to it, but were not to insist upon any special mode of working. All accidents were to be reported within twelve hours. This Act was only passed for five years as a trial.

In the year following the passing of this Act there were three explosions, in which sixty-one, thirty-five, and fifty-two persons were killed. This called the attention of the Government to the matter, and two additional inspectors—one for Scotland and one for England—were appointed. This did not satisfy the workmen, and several petitions were sent in from Northumberland, asking a better inspection and more pits to each colliery. Following this, in less than three weeks there was a succession of accidents causing the death of 138 persons. A select committee was appointed in the beginning of 1853, and they, after finding by experiment that the Davy lamp was unsafe, decided that it was better to improve the ventilation than trust to safety lamps. They recommended the use of the steam jet and the ventilating of goaves by means of bore-holes. They said that there were too few inspectors, and recommended the appointment of twelve, with two assistants each, and a special staff composed of scientific and practical men who were to give instructions to them.

The recommendations of this select committee raised a lively discussion, and another committee was appointed. This committee heard deputations from the workmen and from the Coal Trade Association of Northumberland, who, under the presidency of Nicholas Wood, drew up a set of regulations for mines. The report of this committee formed the basis of the law of 1855.

The chief provisions of this law were the establishment of general and special rules, and of the principle of arbitration between inspectors and coalmasters. There were twelve inspectors appointed for Britain. This law was only for five years, and at the end of that time (in 1860) another Act was passed, which was

substantially the same as that of 1855, the only difference being that the powers of inspectors were extended. The special rules were made for each district, and any dispute between the owner and inspector settled by arbitration.

In 1862 the Hartley accident* occurred, and an Act was passed, without any serious opposition, making two shafts compulsory upon all mines. The workmen still complaining, a fresh select committee was appointed, and they, in 1867, gave in a report recommending that powder should not be employed in mines where safety lamps were used, that not more than 100 persons should be employed in a mine or section with a separate intake and return, and that there should be a barometer and thermometer at each mine. A bill embodying these recommendations was introduced in 1869. This was protested against by the employers on the one hand and by the workmen on the other: the former saying it was much too severe, and protesting among other things against the omission of the words "under ordinary circumstances" from the first general rule; and the latter asking that every manager should have a certificate, that there should be sub-inspectors taken from the workmen, and that all mines should be examined by the inspectors at least every three years. This did not pass, and in 1871 a new Act was brought up in which the words "under ordinary circumstances" were replaced in the first general rule, safety lamps were rendered compulsory in places probably dangerous, and the restriction on the use of powder suppressed. Certificated managers were not required by this Act. This law not being passed in 1871, a third modification was introduced in 1872. In this the words "under ordinary circumstances" were re-introduced in the first general rule, a new regulation inserted relative to the use of powder in fiery mines, a daily visit of the officials rendered compulsory, and the workmen allowed to make an occasional examination of the mine. To this the miners strongly objected, on the ground that any one grumbling would be sure to be dismissed. The discussion before Parliament gave rise to several important modifications, and the

* In this accident the pumping beam fell down the shaft, closing up the only outlet, and causing the death of a number of men from suffocation.

project thus modified gave rise to the Act of 1872, where, for the first time, certificated managers were required. Each of the inspectors got an assistant.

Some difficulties arose in the application of the Act, notably as to whether the certificate of service should be given to the mining engineer or to the viewer. It was thought strange that certificates should be given to men who had charge of a small place, and should be refused to those who were underviewers at a large one; and the government finally gave them to underviewers who could shew that they had had the practical charge of a mine for the time specified by law.

In 1875, after the Bunkers Hill explosion, where 43 persons were killed, a discussion was raised on the using of powder along with safety lamps. This question was submitted to a meeting of inspectors, the majority of whom (six out of eleven) came to the conclusion that it was not advisable to alter the existing law. The accident at Blantyre also called attention strongly to the danger of mixed lights. The large number of accidents in 1878 gave rise to a discussion in the House of Commons, in the course of which the Secretary of State announced that he had issued instructions to the inspectors—Not to visit mines only after an accident; to take notice of all complaints, and not give any information as to the source; to pay attention to anonymous complaints; to visit the pits without previous intimation to the coalmaster, and to take a note of each visit and its result. He also advised the inspectors to put down blasting as much as possible.

Finally, after the two accidents of Dinas and Abercarn, in 1879, the Government appointed a Royal Commission, who are now engaged in discussing the question. It consists of Mr W. W. Smythe, Lord Lindsay, Prof. Abel, Thomas Burt, Prof. Clifton, Sir George Elliot, W. T. Lewis, Prof. Tyndall, Lindsay Wood.

They have already examined some sixty-five witnesses, and have visited some of the collieries where large explosions took place.

It is expected that this Commission will not make any serious alteration in the law of 1872; but will increase the number of inspectors, and give them more power, especially with regard to questions of a general nature, such as the arrangement of working,

the method of working, the limitation of the extent of the workings by a pair of pits, the prohibition of the use of powder where safety lamps are used.

Some new regulations are likely to be made with regard to certificated managers. It is a general cause of complaint that some certificated managers play the part of some editors of newspapers; or are, in fact, men of straw, who take the responsibility in order to relieve the agent or mining engineer, who is the true manager.

Application of the Act.

H.M. Inspectors.

In 1879 there were 12 Inspectors, having the supervision of 3,673 coal mines, employing 476,810 persons, and producing 133,720,323 tons of coal. Several of the inspectors have districts putting out as much coal as the whole of Belgium or France; so that an inspector and his assistant stands in place of the whole corps of mines in Belgium.

An inspector is at the head of his own district, and is practically independent. He is under the Home Office, and in the event of raising a prosecution has to ask permission; but this appears to be mere formality.

There are two meetings of inspectors in London every year, where any special points are discussed. A subject of frequent discussion is the use of gunpowder in fiery mines. There is no attempt to establish a unity of doctrine on this point. In some districts the inspectors wish to have blasting in fiery mines done away with, and have recourse to arbitration to enforce its disuse. This took place in Durham recently, and it was decided that it should not be used.

In other districts the inspectors hold that they are not entitled to arbitrate upon the question, as it is already decided by the 8th General Rule. One of the inspectors told the Commissioners that prior to the Act of 1872 he had been able to prevent the use of powder in mines where safety lamps were used, by having an arbitration; but that since the new law he considered this decision as without value.

If the Act were interpreted as it would be on the Continent,

the powers of inspectors would be as wide as it would be possible to make them. Section 46 is in fact drawn out in such terms that it does not appear very well what would be the matter, whether of practice or theory, upon which the inspector was not able to interfere. Article 50 of the French law of 1810, and article 196 of the Prussian law of 1865, which are the foundation of all the legal systems on the Continent, scarcely differ at all in their wording from this section of the English law. The interpretation and application of the law on the two sides of the channel, however, are very different. For example, it would never be thought that an inspector was authorised by section 46 of the law of 1872 to interfere in deciding the position to give to the pits, the plan and methods of working, &c., although such a section might be considered on the Continent as giving him that power.

It is admitted on all sides that the powers of the inspectors to-day bear very little resemblance to those of the first inspectors under the law of 1850, who had only to take note of the accidents and assist the coroners at their inquests. But to-day, as in 1850, the inspectors remain faithful to the idea, that they ought scrupulously to abstain from all intervention which would interfere with the management of the colliery by the coalmaster and tend to diminish his responsibility. It appears to be admitted as a general principle that anything is lawful which is not explicitly forbidden in the Act or the Special Rules, and that the inspectors would be "without power" (to use their own expression) to oppose it. Thus, an inspector said he would be without power against a mine in which he found the returns full of gas, because the 1st General Rule said that the ventilation should dilute the gas and render it harmless in the working places and roads leading thereto, and did not say anything about the returns.

In a general way, the inspector leaves the coalmaster very much unfettered, and only takes up infractions when they come to his notice as being so formal as to be incontestable.

The inspectors use persuasion to try and get people to cease more or less dangerous practices, or to introduce better ones; but they appear to go about with extreme circumspection.

Official notices are rare, and arbitrations are still more so. These are generally about matters of detail, such as the use of safety lamps.

The cases of arbitration heard of by the Commission were too rare to draw conclusions with regard to this special mode of procedure. Many of the inspectors have never had them. The only case noted was relative to the prohibition of powder in blasting the coal in a mine in Durham. It seems that, as in this case, the umpire, upon whom the responsibility devolves, always takes the side of prudence, and accordingly that of the inspector. Altogether, they do not seem any better than the appeal to the Higher Court provided on the Continent, while they are certainly much more costly.

To insure the Act being carried out, the inspectors frequently send notices to the coalmasters, and sometimes these give rise to prosecutions. These arise on various subjects, but the larger part of them is caused by violations of the 1st General Rule.

Although the manager of a mine is held as responsible, the agent and owner are sometimes prosecuted. Examples of this are given. After the accident at Great Boys Colliery in 1877, the shot firer was convicted for firing shots without having previously examined the working-place; the fireman for not seeing that the shot firer looked after his business properly; and the manager and managing partner for not seeing the 8th General Rule properly carried out at the colliery.

In order to render the system of inspection more serviceable, the Government have striven to impress upon the workmen to send word to the inspector, even by an anonymous letter, when any violation of the law takes place. This is done to a great extent; in some districts more than forty complaints being made in a year, all of which were attended to—the place either being visited by the inspector or sub-inspector, or a formal notice being sent to the coalmaster.

This kind of intervention by the workmen forms a distinctive feature of the English system, and tends in a great measure to remedy the insufficiency in the number of inspectors.

SPECIAL RULES.

The special rules which all collieries have give a great elasticity to the system, as they have the advantage of being easily modified. Each district has rules which are common to all its mines. These rules are somewhat analagous to the French special rules for each colliery *(reglement particuliers)*, although they resemble perhaps more fully the regulations issued by the prèfets. It is evident that when they are applied to such a large number of collieries, some fiery and some not, they must be pretty general.

In addition to the special rules, there are frequently "by-laws" which are not submitted to the inspector, and refer to penalties for absence without leave, &c.

GENERAL APPLICATION OF THE LAW.

The law, as a whole, appears to be pretty well carried out. It may, however, be doubted whether more attention is not paid to the letter of the law than the spirit in carrying it out. Thus, to take an instance, all the reports required by the Act are regularly made; but it is doubtful if much value can be attached to the records formed by them.

On the other hand, great attention appears to be devoted to defining minutely the responsibilities of each person; so much so, that it appeared to the Commission that there was a danger here, as in Belgium, of removing the responsibility from the highest rank to the lowest without any increase in the safety, It must always be borne in mind that, in the most of the English districts, the superintendence has not resulted from the traditions or usages of the place, but it has been neccssary to create it by Government, and, accordingly, to enter into details of the regulation which would not otherwise be required.

A point to which considerable attention has been called in

NOTE.—It is difficult to find officials in French mines corresponding exactly to those of English mines. Thus in English mines the fireman is a special inspector for gas; but, in addition to this, he is an agent in the superintendence corresponding pretty much to the sous-maitres mineurs, sous gouvernours, or chefs de poste in French mines. He corresponds still more closely with the Belgian surveillant, who is more a seeker for gas. All the maistrance and sous maistrance of English mines have been created by the legislation. The word "fireman" has been borrowed, in some districts, from the name of the workman who used to light the gas, or the penitent of the Loire.

France is the difficulty of defining a fiery mine. The English law of 1872 has been cited as an instance where a distinction has been drawn between mines in which gas has been seen for three months and those in which it has not been seen for twelve months. This distinction appears to be wholly theoretical, and is not attended to at all in practice. The visits of the firemen, and blasting, are organised once for all after the system proper to the mine, and are in conformity with the special rules of the district, and these are the same whether the mines are fiery or non-fiery.

The general opinion in England is that the act has done good, and that accidents have diminished since its passing.

CONDITIONS UNDER WHICH GAS IS FOUND.

The most fiery districts in England are those of South Wales, Lancashire, Yorkshire, and perhaps East Scotland and North Stafford. In each district, the accidents are generally limited to one or two seams

In South Wales, there are three districts—Risca-Abercarn, Aberdare and Rhondda, and Bridgend, Swansea. In the Risca-Abercarn district, the seam principally worked to a depth of 160 fathoms is the black vein, and in that of Aberdare-Rhondda it is the Aberdare upper four-feet.

In Lancashire, the most fiery districts are the Wigan and St Helens, the most fiery seams in which are the Arley and Wigan nine-feet. These two seams are perhaps the most fiery in England.

In Yorkshire, in the Barnsley district, the two most fiery seams are the Barnsley and Silkstone, the one at a depth of 285 fathoms below the other. Outside the Barnsley district, the Yorkshire seams are not very fiery.

In the north, the fiery seam is the Hutton, when it is from 170 to 300 fathoms deep, as it is near Sunderland.

In Scotland, there are few fiery seams, except in the eastern district of Lanarkshire, round Hamilton, the only district visited by the Commission. The mines here are deeper, and the rocks are covered with clay surface.

In all English districts, the seams get more fiery as they get deeper.

From the examination made by the Commission, it did not appear that any of the seams had any great disengagement of gas. Certainly, none of them had any discharge like those of the seams in Liége Seraing or the Midi, or the West of Mons, where the place could not be kept clear when the coal was being taken down, even although there was a very strong current of air.

On the other hand, there is no doubt but that English measures in fiery districts contain large volumes of gas which may come into the seam worked. These may either be due to natural causes, or to the mode of working. Whatever it may be due to, there are, there can be no doubt, blowers or sudden outbursts of gas, as well as influxes of gas from old workings.

In many instances gas comes from other measures than coal, as in sinking a pit at Lhoynpia, in the Rhondda district of South Wales, a blower was met with coming from a seam of grey shale with such force that, when it was led from behind the walling to the surface by a pipe, it lighted the whole place. This continued for years.

EXCEPTIONAL DISENGAGEMENTS OF GAS.

These are of two kinds, blowers and sudden outbursts. They do not appear to be the same kind of instantaneous disengagements as those occurring in Belgium, where the gas bursts out instantaneously from the solid coal, throwing down large masses. In England, they generally come from the roof, and very seldom from the solid coal. They sometimes break out in such quantities as to fill the pit, and the Commission quote several examples. It frequently happens that where the crack or fracture is pretty clean, water comes from the hole as well as gas. At Corton Wood, in the Barnsley district, a blower with water was found, and the gas came from it in such quantity that for two and a half hours the air was inflammable at the ear of a Guibal fan, which discharged 198,000 cubic feet per minute. These blowers are very frequently found near faults.

A blower is distinguished from a sudden outburst by the fact that it comes from a fissure which exists in the rock, and the gas only comes out when this is cut. In a sudden outburst the

coal is burst off by the gas. These come sometimes from the roof and sometimes from the side. They take place frequently in the Barnsley and Silkstone seams in Yorkshire, and have been carefully studied by the engineers there. They sometimes accompany a break in the roof and sometimes burst out of the coal; the length of time during which they continue varying from two or three days to a few hours.

At New Oaks, a mine to the direct dip of the Oaks, where an explosion took place on the 30th August, 1876, an outburst took place in the longwall workings of the Barnsley bed, which were aired by a current of 10,500 cubic feet per minute. The returns were so much charged with gas that the Mueseler lamps were put out at the bottom of the upcast shaft, where there was a current of 138,600 cubic feet per minute.

These sudden outbursts may explain many accidents; but it is not surprising that on the one side they are strenuously upheld as being the cause, while on the other they are as strenuously denied. There is no doubt they do happen, but there is still the difficulty to explain whether a given accident was caused by them or not.

The engineers in Yorkshire, who have carefully studied this question, have come to the conclusion that no amount of ventilation will be sufficient to overcome these sudden outbursts, and that the only chance of safety is to have self-extinguishing safety lamps, which must be kept in perfect order, and have the men under the most severe discipline. They recommend that powder should be done without as much as possible.

It did not appear to the Commission, however, that the method of working had nothing to do with these outbursts.

In the first place, the break through which the outburst took place was caused by the method of working. In all English workings, whether by pillar-and-stall, or long-wall, the principle is not to fill in the goaf totally, but to allow the roof to fall and fill it up. When, as in Yorkshire, the progress of the stalls is very rapid, great strains are put on the roof, and the pressure of the gas must be much increased. If the workings were conducted on the principle of taking small sections and stowing up every place carefully as the coal was taken out, with rubbish brought

down from the surface if necessary, the roof would not be subjected to such strains, and the pressure of gas would be more regular. The question has never been examined from this point of view in England, where working with rubbish brought from the surface seems altogether unknown.

The gas which causes these sudden outbursts sometimes comes from seams of shale and coal below the worked seam; and at a borehole put down from the Silkstone seam to a seam ten fathoms beneath, a pressure of 90 lbs. on the square inch was got. The gas flowed through a 2-inch hole at the rate of 35 cubic feet per hour. The Wigan nine-feet seam has a small seam seven fathoms below it from which the gas comes, and, in order to relieve pressure, boreholes are put down at stated intervals with very good effect. Although boreholes have been tried in the Barnsley district, they do not seem to do much good.

In addition to outbursts of gas from the pavement, there are outbursts from the roof, and in addition to both of these there is the danger of the invasion of the gas from the goaf when a fall of roof takes place.

The English fields being so flat, and being worked to such a large extent from a pair of pits, which are close together, are very unfavourable for being drained of gas. Although there is no great normal discharge, they are evidently liable to outbursts of some kind, whether from the coal or the waste, giving rise to catastrophes which, although they are few in number, are very serious.

The reason why so many persons are killed in an explosion in England is,—that in a flat seam with a large extent of workings from a pair of pits which are close together, the divisions are not so well separated that an explosion in one will not affect the others. In fact, the slightest explosion blows out the air crossings and destroys the air current. Few of the workmen die from burning; the most of them are suffocated.

There are varieties of gas found in different districts. Thus, returns shewing a cap of one-third of an inch in the Wigan district are said to be more dangerous than those shewing one inch in the South Wales district.

ARRANGEMENT AND WORKING.

The seams in all the English districts lie with a regularity quite unknown in Belgium or France. They are very numerous,—there are nearly 100 in Wales, of which 25 are workable,—and have a thickness varying from 22 inches to 10 feet in South Wales, to 30 feet in the ten-yard coal of South Staffordshire. They are very level, the inclination generally varying from 1 in 40 to 1 in 6.

The coal is generally, especially in Wales and Scotland, jointed so as to make it more easily wrought in one direction than another.

The roofs are generally much more solid than those met with in France, and this perhaps tends to cause some of the accidents, from sudden outbursts of gas coming from old workings and invading the working places.

The small faults running through the districts appear to be pretty regular, and aid the working by dividing off the workings into districts.

LEASES.

The minerals belong to the proprietors of the surface, who grant leases to the coalmaster, the duration of which varies from 19 to 30 years in Scotland to 90 years in most other places. The acreage in a royalty varies from 50 acres to 6000,—the average in Scotland varying from 125 to 250 acres.

The rent is payable on the number of tons wrought, on the area wrought, on the volume wrought, and on a proportion of the selling price, frequently one-third in South Staffordshire. The lordship may be as high as 8d to 1s a ton, but is generally from 5d to 6d. There is always a minimum fixed rent.

This system of letting gives a very crooked outline to the properties, and the number of small properties sometimes causes a large number of pits to be sunk.

The transitory nature of the tenure, however, prevents the coalmaster from laying out more money than he can help, and thus we have a single fitting, working coal three or four miles from the intake and return pits; and this is undoubtedly one of the causes of the large accidents which happen yearly in England.

This situation also leads to the irregular working of seams on account of their different commercial values. Thus a lower seam and a higher may be worked at the same time, while an intermediate one is left unworked. The cavities formed by falls of roof, &c., may get filled up with gas from this seam, and any fresh fall may drive it out, and so form a sudden outburst.

The fitting is erected where ground is to be had, labour is at hand, and means of transit ready. These considerations appear to have most weight in England, and they are important, but they should not cause to be forgotten other considerations which involve the safety of the workmen.

The extensive use of underground machinery for haulage and pumping makes the position of the pit, with reference to the dip and rise, of less importance, and we have seen pits placed at the corner of fields, or with a considerable amount of coal to the dip, so as to suit the surface arrangements. Generally, except in Scotland, the extent of workings by a pair of pits is greater than on the Continent. As an instance, the Thrybergh Hall Colliery, in Yorkshire, has workings extending 2,600 yards to level, on the one side, 3,500 on the other, 2,200 to the rise, and 1,700 to the dip.

The coalmaster in England is a tenant whose object is to get the greatest amount of profit from a fitting in the least possible time, and with the least possible expenditure of capital. In general, the largest expenditure is in the pits, which are of no value when the coal is exhausted; and instead of sinking others he uses engines which belong to himself, and may be sold when the colliery is finished, to draw the coal through roads which are always in the coal, so that the cost of forming them is paid from day to day by the coal coming from them. The seams are so flat and regular that they allow of a great horizontal extension without much vertical; so that when a valuable seam is reached the workings are carried on for a long time in it.

The chief inconvenience of this enormous development of workings in the same seam, is the necessity of having the intake and return pits so close together that it is impossible to divide the currents of air properly without the use of crossings, which, when an explosion takes place, are all blown out, and the ventilation destroyed.

ARRANGEMENT OF PITS.

The fittings are variously arranged.

1. Two pits of large diameter placed near one another, one with powerful machinery and used for winding and pumping, and the other for an upcast, with an arrangement for raising the men in case of necessity.

2. The same with the upcast with smaller engines, so as to continue the output if anything goes wrong with the large one.

3. The upcast and downcast fitted with equally powerful engines.

4. Twin pits—the same engine drawing from two pits.

5. Three pits of large diameter—two for winding and downcasts, and the other an upcast, sometimes winding.

6. Four pits—three downcasts and winding pits, and the upcast winding.

The Commission only saw two instances of diagonal ventilation—*i.e.*, ventilation where the line between the downcast and the upcast forms the diagonal of a parallelogram, the sides of which are formed by the workings—the one at Dinas, in South Wales, where the pits are 550 yards apart, and the other at Abram, in Lancashire, where the pits are 500 yards apart. Pits with this form of ventilation are not more free from accidents, as at Pen-y-graig and Dinas large explosions have happened, and recently at Abram.

The great tendency in England is to concentrate the machinery for ventilating and winding to one point, and to have them of a size quite unusual on the Continent. This position is chosen without any regard to the underground requirements. In not subordinating all the arrangement of the interior workings to the concentration of enormous productions at a single point at the surface, one is able perhaps to arrive at a better use of the forces employed, to a better employment of the immense volumes of air set in movement in English collieries; and, above all, to a greater security in working, without which the economic result would be inferior to the assuredly very remarkable results which are obtained in English mines.

The writers review the manner of shutting off the upcast shaft when coal is raised in it, and give a sketch of the arrangement at

Bickershaw, where a 43ft. Guibal fan gets air from both sides, and has compound engines, one cylinder being at each side of the fan, and the one exhausting into the other. They are of opinion that the valves employed for shutting off the tops of the upcasts have been very much better studied on the Continent than in England. The best valve they saw was that at Dinas, made by Mr Galloway. This was a light framework of sheet iron, balanced by weights, and the jar of the rope taken off by springs.

They, also, highly approve of the method of making the cage fit the shaft, and having a sliding door which is opened when the hutch is to be changed.

In England the pits are round, and built with brick. In Scotland they are rectangular, and lined with wood; but even there, in doubtful strata, they are sometimes made round.

There is seldom a pit for a special purpose. The downcast is generally used for winding, and the upcast for winding and pumping. Sometimes, as at Blantyre in Scotland, a portion of a pit is kept separate from the rest as an upcast.

As a rule, the interior of the shaft is kept as free as possible, room only being taken up by the slides, the only division between the pumps being the needles.

In some cases, as at Harris' Navigation, the needles are put in of channel irons, instead of wood, and iron rails used.

There seems to be a bold and happy use of wire-rope guides.

The Commission point out that pits of large section are frequent, but often the section of the upcast is much less than that of the downcast. This small diameter of the upcast, by creating a great resistance, is one of the things which prevent the introduction of fans, instead of furnaces.

There is no intervention whatever, on the part of the Inspectors of mines with the organisation of the fittings. They have no special powers to interfere, and they allow the coalmaster to have his own way. Only one of the Inspectors whom the Commissioners met, saw any objections to winding coal in the upcast of a very fiery seam.

In working one seam in England everything is done in it. If two or more seams are worked there is only one landing for each cage, and the coals from the other seams are either run down a

crosscut mine to the level, or let down a blind pit. Even in highly-inclined seams the English do not make use of crosscut galleries for ventilating purposes as is done in Belgium. If they have a crosscut it is a single one, and the coals are drawn to it by mechanical haulage, and it frequently remains dead so far as the ventilation is concerned.

In a general way, in an English pit each seam constitutes a stage in the working and ventilation. The air of this stage leaves the downcast generally by the chief haulage road, and after going round the workings, returns by a road parallel to it, and within a short distance of it. From this arises the impossibility of dividing the enormous volumes of air which are necessary to ventilate workings so developed as the English ones otherwise than by very numerous crossings and doors.

The average annual deepening of the mines in England is much less than in Belgium; and it may be thought that as they are shallower they will be less fiery. Any advantage, however, which would be gained by this is lost by the great extension of the workings, which renders it extremely difficult to ventilate the working faces. The English try to overcome this difficulty by large airways, frequent divisions of the current, and by sending in huge volumes of air. On the Continent these are looked upon with great admiration, but when the subject is investigated, it is found that in reality only a small proportion of these large currents goes past the pit-bottom. The mode of ventilating drifts in England is invariably to have two and join them by throughers for air. These throughers are closed up by a brick wall—two or three bricks thick, built with mortar or cement—at each end, and the space between sometimes filled in with small coal, and sometimes left vacant. In any explosion these are all blown down, and their absence prevents the renewal of the air current.

The doors for separating currents of air are usually made very large, a fault which is not remedied by the care with which they are constructed.

In the north the doors between the intake and the return are locked, and it is the duty of the master wasteman as specified in the special rules to look after them.

At Celynen, the committee saw a safety door between the two main doors. The space between was built with brickwork, and the door caught with a catch, so as to be easily closed.

Air-crossings are made of various forms in England. They are made with brick walls and a wooden cover, with a sheet iron tube, or with a brick arch.

They are all liable to the same objection, that when an explosion occurs it knocks them all out and destroys the current in the part ventilated by them.

In order to avoid this risk, they are frequently made in rock at a sufficient height to be unaffected by an explosion. In some places pits have been made to an upper seam which is unworked, and a crossing made in it, or the returns carried to the upcast.

The general plan of all English workings is to have double or triple parallel drifts with workings to each side.

These drifts are driven level course, and to the dip and rise when there is a slight inclination; level course and in diagonal lines when the dip is great; and in any direction which will suit the form of the royalty when the field is flat.

The Commission give a plan of the Hutton seam at Eppleton, (see plate I.,) and say that the goaves appear to be scattered about it in a very capricious way.

They seem very much struck with the utility of canvas bratticing, and recommend it very highly for use after an explosion. They also notice the entire absence of pipes in ventilating close places in fiery mines.

One of the best studied points in English collieries is the size of the intakes and returns. The intakes are generally the main haulage and travelling roads, the former of which is frequently bricked, and the latter is kept for the workmen to travel in. These roads are generally better proportioned to the quantity of air which has to travel in them than on the Continent. The exceptional solidity of the rocks in England allows it, while in France none of these large areas which have often caused astonishment on that side of the channel could be maintained.

The returns are drifts parallel to the intakes and within a short distance of them.

The drifts into the pits are generally from each side, and when

the air is sent in at the same level as the furnace, it is generally in fiery mines sent round the outside of a brick chimney to such a height that there is no danger of its touching the flame.

The secondary air-ways are also generally larger in England than on the Continent. This is owing to their being made in the coal, which causes their cutting to be easier, and to the exceptional solidity of the surrounding strata.

In the workings themselves the passage for air is generally larger than in France or Belgium. This is due to the thickness of the coal and the strength of the roof; but the nearly general absence of stowing, at least of complete stowing, gives the air much more space to travel in, and it is not nearly so well conducted to the face of the coal so as to clear it of fire-damp. Besides this, the absence of stowing and the method of robbing the pillars frequently makes it very difficult for the air to pass from one stall to the other.

As a general rule then, the air-ways in England are much larger than those on the Continent.

METHODS OF WORKING.

All the methods of working in England may be divided into three classes :—1, pillar-and-stall of North of England; 2, Lancashire pillar-and-stall and the Welsh double-stall; 3, long-wall.

The first may be divided into two kinds—1st, that in which the pillars are left in; 2d, that in which they are taken out.

The first method is carried out when it is wanted to keep the surface uninjured. At the William Pit, near Whitehaven, they work under the sea for a distance of more than 2200 yards, by a pit whose workings on one side extend for 4400 yards to the dip. The seam worked is the main band, which has a thickness of 10 feet and an inclination under the sea of 1 in 7. The workings are about 130 fathoms under the level of the water.

The main drifts are 11½ feet wide and 7½ feet high, and are separated by a pillar 11½ yards wide, with openings every 20 yards.

The field is broken up into panels by drifts 11 feet wide and 7½ feet high, pillars 20 yards square being left between them. Each panel has a width of about 150 yards, and goes on till it meets with a fault or something which stops it.

When this first working is finished, the pillars are split by an 18 feet place. In all these workings only 7½ feet is taken out of a total thickness of 10 feet, the 30″ being left to keep up the roof which is not very good. The working in each place was done by two men paid by the ton, and putting out two tons each in a shift of six hours.

The brattice in each place was carried in by means of lengths like the lid of a packing box.

There was a very strong blower in one of the drifts at a fault. At the face the gas was perfectly swept away by the current, but outside the brattice which led the air to the face, and consequently where the area of the drift was the whole size and the speed of the air a half less, the half of the height of the drift was so full of gas that a lamp put in it filled and exploded immediately.

When, however, the workings are not below the sea, the whole coal is taken out. The pillars are left as large as possible and the drifts as small. The pillars generally represent 70% of the whole.

One system seen at Blantyre, in Scotland, is to go to the boundary with the close places, and then come back, taking out the pillars. The chief objections to this system are the large number of open drifts and the increased cost of working for a long time, due to so much strait work. This has given rise to working in panels, so that there is a uniform price throughout. This method is largely employed in Durham. The districts are generally from 200 to 400 yards wide. The shape of the pillars is generally either square or rectangular, and the direction of the long side is regulated in steep fields by the dip and rise, and in flat fields by the cleavage planes. The Commissioners describe the working off of the pillars, and instance Ryhope where they take off 40-yards pillars by lifts, uphill, all the length of the stoop, the last lift being taken off by cross lifts; and Haswell, where lifts are taken off the pillar from both sides, meeting at the centre, with a pack-wall built between the road and the goaf.

The Commissioners do not seem to think very highly of the system of ventilating stoops while they are being taken out, even

though they are under the impression that a line of props is left between the coal and the goaf so as to leave an open passage round the edge.

The system of going to the extremity of the field with pairs of drifts and coming back with the block between, as practised in Lundhill and Pendlebury Collieries, which were visited, and the working described by the propping deputation, is fully gone into by the Commissioners. They say that the ventilation is often no better in this method than in stooping with ordinary stoop-and-room workings. This is caused they say, first, because of the enormous losses by doors, screens, and stoppings, fixed or movable, which are multiplied to an infinite degree; and, secondly, because the air is very imperfectly led from the air-course to the face. Very often there is no stowing, and the only thing to guide the air round the face is the rubbish from the fallen roof, which is not built in any way, but is simply allowed to remain as it falls, so that the air is perfectly free to take the shortest way.

The Welsh single- and double-stall systems are described, and the former characterised as being very badly ventilated. They remark that both systems have the inconvenience of forming cul de sac, which are sure to be full of gas on each side of pillars supporting the main road.

The Commissioners find fault with the whole system of stoop-and-room working, as they say there are large cavities formed, and the falls of roof drive out the gas which accumulates in them. If the roof does not fall, then the cavity remains and forms a reservoir, the contents of which contract and expand with every rise and fall of the barometer.

The methods of long-wall are described by the Commissioners who say that, generally, long-wall workings are much better ventilated than stoop-and-room ones, because the face is better arranged for passing air, and the stowing is much better placed for keeping it near the face. This is especially the case where the roof comes down regularly, and within a short distance of the face.

The chief inconvenience of long-wall is when the roof and the seam do not give sufficient rubbish to stow the goaf. The working then creates spaces in the roof quite as dangerous as those in stoop-and-room workings, and the ventilation is defective. The

drawing roads and air-courses are very difficult to keep up. To maintain the incontestible superiority of long-wall it would be necessary to take down stowing from the surface, but the immense competition to which the English collieries are subjected does not permit of this. A penny or two more or less in the cost of working absorbs all the profits which they might make, or augments the loss actually being made.

The following are the characteristics of English working, whatever the variety adopted :—

1. The great length of workings in each seam which always form a distinct section communicating with the surface only by the two pits.
2. The arrangement of workings in the seam into sections having only an intake and a return by parallel roads near to one another.
3. The order of working these sections being subordinated to a large output so that very often the intakes and returns to the workings in operation have goaves on each side.
4. The absence of stowing carefully arranged so as to lessen the danger presented by old workings, which are filled with gas.
5. The extremely rapid exhaustion of seams of average thickness causing sudden falls of roof which are liable to be accompanied by outbursts of gas.
6. Blasting in coal often without any great precautions.
7. The practise of nearly always taking horses to the face, leading to the neglect of doors. Frequently 200 or 300 horses are in a pit, and these should be taken into account when calculating the useful effect of the ventilation.
8. The fact that, unless in long-wall, there is no sufficient road kept round the actual face of the working. The usual practice is to leave a row of props along the goaf edge, but in no case were the Commissioners able to get round.
9. The multiplicity of crossings, doors, stoppings, screens, &c., joined to the want of stowage causes such a leakage that out of the enormous quantities going down the shafts very frequently smaller quantities get to the face itself than in the Belgium mines where only 60,000 to 80,000 feet per minute go into the large collieries.

In a general way the seam is worked all round the pit, and as the pits are close together all the workings to the rise form an immense reservoir for gas, without any natural issue. It is thus evident that any point which is not directly in the line of the artificial current forms a reservoir where gas must necessarily accumulate. If one reflects, that in the immense stretches thus worked about a fitting there is no other stowing than that furnished by falls of roof, he becomes dismayed from the importance of the reservoirs of gas which must be created by the system adopted in most of the collieries, and will comprehend the gravity of the accidents which will happen from it.

Although all the Inspectors consider the method of working very important to the safety of the workmen, and although some of them have told us that they have found it safer to work with naked lights and powder in a seam worked in a good method, than with safety lamps and without powder in a seam badly arranged, all of them consider, that so long as a method of working has not given rise to accidents they have no opinion to give on the subject, and we have been informed that even if an accident does take place, they do not consider themselves authorised to interfere. They find that they must leave the coalmaster to arrange his own working.

Ventilation.

The Commission did not see a single mine ventilated by natural ventilation only, although there are some in South Staffordshire.

Fiery mines in England are ventilated by furnaces or fans, and although the former are still more numerous, especially in the North of England, fans are gradually taking their place.

The Commission give a full description of Lundhill furnace.

Furnaces are generally fed with the air from the returns. It is only in rare instances that fresh air is taken to feed them.

The fans most commonly used in England are the Guibal, the Waddle, and the Schiele.

The first is the most widely spread in England, and the second in Wales.

The Guibal fans are similar to those on the Continent.

They are, however, larger, the largest on the Continent being 39 feet diameter, while that at Abram is 46 feet. With one exception, all the fans seen by the Commissioners got their air from one side only.

The manometric efficiency of the nine fans seen in England happens to be very nearly the same as that of the 29 seen in Belgium.

	Belgium.		England.
Mean, ...	·608	...	·611
Maximum,	·737	...	·715
Minimum,	·441	...	·441

The three Waddle fans gave a manometric efficiency very similar to the Lambert fans in Belgium.

	Lambert.		Waddle.
Mean, ...	·394	...	·413
Maximum,	·455	...	·456
Minimum,	·312	...	·378

The Schiele fan is one with small diameter and great speed. There is a discussion going on as to whether the high-speed fans are more economical. The manometric efficiency of the Schiele is—

Average,	... ·322
Maximum,	... ·400
Minimum,	... ·203

They thus give only half the water-gauge of a Guibal, with the same speed of periphery. The advantage claimed for them is that they give a larger proportion of useful work, and this is shewn by a Mr Merfyn in a paper to the British Association of Mining Students. The greatest speed of periphery is got from the large fans, 127 feet per second being got from the fan at Celynen. The mean water-gauge of the twenty-four mines visited was 2·82 in., with a maximum of 8½ in. at Seaham, and a minimum of ½ in. at Allanshaw.

The following table gives the water-gauges produced by fans and furnaces :—

	Furnaces.	Fans.
Number of mines,	8	16
Mean water-gauge,	4·31	2·1
Maximum,	8·38	3·35
Minimum,	2·23	0·50

The high water-gauges necessary in some fittings explain the reason for having furnaces instead of fans. Thus, to produce the water gauge of 8·38″ at Seaham, a 46-feet Guibal fan, with a manometric efficiency of ·650, would require to be driven 71 revolutions per minute. If the Seaham pits, however, were 16½ feet diameter, instead of 14, the water gauge would only require to be 7$\frac{1}{6}$″, and the number of revolutions 65, which, however, would still be too great, and recourse would probably have to be had to having two fans, the one exhausting into the other.

The equivalent orifice for 22 mines gives an average of 34·4 sq. feet, with a maximum of 63·42 at Murton and a minimum of 13·1 at Whitehaven. The English mines have thus large, or very large, equivalent orifices. This result is owing to the character of the seams. The absolute quantities are very great. Thus at Seaham there are 360,000 cubic feet per minute. One might imagine at first sight that this meant a wonderfully good ventilation, but when it is gone into it is found to be no better than on the Continent.

The following tables give the number of cubic feet of air per minute, per man employed, for 18 mines in England and 15 in Belgium ; and the quantity of air, per ton raised, for 24 mines in England and 9 in Belgium :—

	PER MAN.		PER TON.	
	BELGIUM.	ENGLAND.	BELGIUM.	ENGLAND.
Mean, . . .	189	395	174	209
Maximum, . .	325	705	353	430
Minimum, . .	82	215	62	65

Comparing the two sets of figures, while it is seen that the

English mines have nearly double the quantity of air per workman that the Belgian mines have, there is nearly the same quantity per ton raised. It must also be borne in mind that, taking into account the number of *colliers* only, the quantities of air per collier are sensibly the same.

The only superiority of English mines over Continental ones is their concentration, which is rendered easy by the the division of the currents, and this is only obtained at the expense of security.

The superiority of England over the Continent disappears if the splitting of these enormous volumes and the manner in which they are used to dilute gas is taken into account. From a large number of registers of the quantities of air passing through workings, it appears that from 25% to 50% of the air coming to the bottom of the shaft is only employed for secondary purposes—such as the ventilation of stables, feeding of boilers, &c.—not taking into account the simple leakages, through doors, stoppings and crossings round the pits. It is not said that this air serves no useful purpose, but it serves scarcely any so far as the dilution of gas is concerned. The remainder of the air is also subjected to various losses, through going in a long way parallel to the return, and separated from it only by brick stoppings, the tightness of which is always doubtful. Thus, to take an example :—

In Eppleton Colliery, Durham, there are three seams worked—the Main, Maudlin, and Hutton—and the following are the quantities of air in each .—

	Cubic Feet per Minute.
Main Coal, ...	84,640
Maudlin, ...	23,700
Hutton, ...	95,302
	203,642

The following table shews the measurements of the air passing

the various stations in the workings of the Hutton seam of which Plate I. is a plan :—

Station.	Cubic Feet per Minute.		Station.	Cubic Feet per Minute.		Station.	Cubic Feet per Minute.
1	3,182						
2	3,068						
3	9,987					11	2,793
4	5,535		7	13,828		12	4,972
5	71,224	73,530	8	1,210		13	6,204
6	2,306		9	41,548	55,530	14	3,737
			10	13,982		15	13,300
Total,	95,302					16	6,492
			Total,	70,568		17	5,734
						18	7,789
						Total,	51,021

From this table of measurements, it will be seen that out of a quantity of 95,300 cubic feet per minute entering the Hutton seam by the two downcasts, only 55,500 cubic feet go into the workings,—that is to say that 42% of the air is lost round the pit bottom.

The average quantity of air received by each of the nine sections is 5,700 cub. ft. per minute. This approaches and is perhaps even more than the quantity of air given in Belgium to a face on one side of a section of a fiery seam; but there the conditions are altogether different. The quantity noted for a Belgian mine is that of the air arriving at the entrance of the section, and which goes to the upcast by drifts walled so as to prevent all loss of air; but in England, after the air has reached the section, it has yet several hundred yards to travel, sometimes in a road between two goaves, before it arrives at the faces. Finally, the quantity of

air arriving in the neighbourhood of the working-places may be less than that arriving at the face itself of a Belgian mine where the losses do not exist to the same degree. To sum up, it might almost be said that in the working-places themselves, the ventilation is made by diffusion alone. Some of these sections might produce 120 tons a shift and contain 24 hewers and 6 drawers, or 30 men.

It would take too long to go over other mines in such detail, but they would give very nearly similar results, with an advantage always more or less marked for the long-wall method, where the passage of the air along the face is better secured.

It is generally recognised that a section of long-wall such as has been described should get from 10,000 to 15,000 cubic feet of air per minute. It is curious to find that this is the figure of the large faces of Borinage, only in England the production for the same face is much greater.

In summing up, from all the information the Commission were able to gather on the subject they were led to the conclusion that if at the bottom of English pits enormous volumes are disposed of, the quantities of air really and usefully employed in the working-places are, taking everything into account, inferior to those found in Belgium and in France, and the circulation of air in the working-place itself is not nearly so well arranged for clearing it of gas.

That the system of ventilation is normally sufficient with the nature of English seams must be admitted, as it is followed in the practice of so many eminent engineers; only it explains very easily the facility with which these sudden outbursts which occur in a quarter, charge the atmosphere to a point which renders it explosive.

DISTRIBUTION OF THE CURRENT OF AIR.

To recapitulate, the air in English mines is divided, first, into the different seams and, secondly, each current in each seam is sub-divided into several divisions. The first division is perfect, but the second has really no value as separating one section from another in the event of an explosion, as it depends wholly upon crossings, stoppings, and doors, which have too often proved totally insufficient.

The size of the air-courses is very great, the main airways in a section having from 40 to 50 sq. ft. area, the main airways 70 or 80 sq. ft. Near the pit bottom, where the whole current is collected, the area is sometimes 270 to 300 ft. These airways are kept up with such care that the velocity of the current is generally from 3 to 6 ft per second. The length of the current is frequently two or three miles. One six miles long was seen at Ryhope.

In England, no attention whatever is paid to having the ventilation ascensional, and there is probably not a single colliery which has not some current which is in opposition to the Belgian laws. They only care to have "an adequate amount of ventilation," as the first general rule puts it, and do not care how it is attained.

At many English collieries, daily measurements of the air are taken, and at some special plans shewing the ventilation are kept. This is done with great care at Eppleton, where the airway is lined with boards so as to facilitate the measurement of the air. The readings appear to be very accurate.

At Oak Colliery there is a very simple arrangement for registering the speed of the fan. On the shaft of the fan is a worm which moves a pencil at a speed proportional to that of the fan. This pencil draws a line on a cylinder turned by a clock, and so records the velocity of the fan.

INFLUENCE OF VARIATIONS OF ATMOSPHERIC PRESSURE ON DISCHARGE OF GAS.

The Commissioners are of opinion that, although barometric observations are required by Act of Parliament and made, very little faith is put in them, and the belief seems to be general that a fall in the barometer is not of much importance in mining. The only place where they found any belief in the effect of a fall of the barometer was in Durham, and this they attributed to the method of forming large open goaves, filled with fire-damp which came out with the slightest fall in the barometer.

They mention that there was an opinion in France that the effect of the barometer would be felt to a greater extent in Eng-

land than in France, on account of natural ventilation and furnaces being more used. They point out that there is no natural ventilation in fiery mines in England, and that, as the water-gauge is generally higher with a furnace than with a fan, the effect is really less. A description of the organisation of an English colliery is given, which seems pretty nearly correct.

The Commissioners complain that the daily reports are signed in a very formal manner. They say that the 30th general rule is not observed by the workmen.

The law, by the 6th general rule, which prescribes that all dangerous places shall not be worked in, admits that no working in gas should be permitted, and this enactment is carried out. The Commissioners only saw one instance where a man was working in a place where there was gas, and there it was in a hole in the roof of a close place. In practice, the officials judge if the place is dangerous or not, and whether it is worked or not depends on their judgment. It appeared to the Commissioners that, generally unless there were bad arrangements for ventilation, either there was no gas at all in the place, or there was such a quantity that no one would think of working in it. In fact, this question has not the practical importance in this country that it has in Belgium, where there are seams with a much higher normal disengagement. The haulage and travelling of workmen is generally done in the intakes, but when it is more convenient to use the returns for these purposes, they do not hesitate to do so.

LIGHTING OF THE WORKINGS.

One of the most characteristic traits of English mining is the widely-spread use of naked lights in fiery mines. Safety lamps are often adopted even in freely fiery mines only as a last resort, and after grave accidents have taken place. Both owners and workmen object to their use, on account of the poor light given, and they say that there are more accidents from falls of roof where they are employed. They say that, taking everything into account, there would be more lives lost if safety lamps were rendered compulsory than if naked lights alone were used. Some even go as far as to say that as much attention would not be paid

to the ventilation were safety lamps rendered compulsory, and that with naked lights workmen are more prudent and do not venture into old workings.

However, people are now beginning to adopt safety lamps alone pretty largely in fiery seams, and this is being done more as a precautionary measure than a necessity.

From what has been said, it will be seen that no difficulty is made in the way of mixing the lamps, so as to have naked lights and safety lamps in the same pit. In such a case they are either in different seams or in different sections of the same seam, the point beyond which naked lights are not to be taken being marked by a board.

No particular care appears to be taken in England to use the best kind of safety lamp, although the defects of some of the lamps are fully realised.

At some places there are apparatus for testing the lamps. These consist at Pemberton of a bell of gas at the window of the lamp-cabin where any of the workmen can test his lamp. Mr P. W. Embleton's ring seemed the most simple and efficacious means of testing the lamps. In this arrangement the lighted lamp is passed up and down through a ring with holes in it, through which gas is forced.

In none of the mines are the lamps lighted at the surface only. In the most strict there are always lamp-cabins in the intakes, where an extinguished lamp may be opened and relighted. This is always done by an official, and in no case did the Commissioners hear of keys being kept in the lamp cabins, so that the men could lock their own lamps. The Inspectors of Mines do not interfere in the practices of lighting the safety lamps, so long as there is a competent person, in terms of the 7th General Rule, who examines the lamps and sees that they are locked.

The employment of powder in fiery mines varies according to the district.

Thus in South Wales, where the cleavage of the coal is very regular, they only use powder in fiery seams in brushing the roads, and this is done at night.

In Yorkshire its use has been wholly given up in the Barnsley and Silkstone seams; in the latter seam the brushing is done by picks.

In West Lancashire, powder is freely used in the coal, while in Wigan, it is only used when it can not be done without. In the north, powder is used wherever it is found necessary. They only avoid using it in front of the goaf where they are afraid of finding gas.

Generally, it may be said that in England there is very little restriction put on the employment of powder in fiery seams. Many engineers are even inclined to think the workmen use it to a larger extent than is economical.

The employment of powder in fiery mines appears to be left pretty much to the discretion of the manager.

This is one of the vexed questions of public opinion in England. The idea is constantly cropping up that the use of powder in fiery mines should be strictly forbidden.

At East Hetton the Inspector thought the practice of using powder was unsafe, and on having an arbitration it was decided in his favour by the umpire.

The Commission cites this as an instance of the Inspectors' using the power granted them by the 46th section of the Act, which they appear to think will allow them to do almost anything.

I have noted some of the most important points in this Commission's report, but there are no doubt many others that might have been taken up. Altogether, it is a most careful report, and well worthy of a complete translation. One cannot but admire the industry of these gentlemen, who, in such a short time—for they were only a month in England—have been able to collect so much useful information, and put it in such a readable form.

NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES.

Professor J. S. Newberry, in a Paper on the PHYSICAL CONDITIONS UNDER WHICH COAL WAS FORMED, contained in the American SCHOOL OF MINES QUARTERLY for April, criticises a theory lately advanced in France by M. Grand Eury and M. Fayol; that the carbonaceous matter of which coal is composed has been derived from plants deposited by means of water at a greater or less distance from their place of growth. The mode of occurrence of some of the Ohio coal beds, and the nature and order of the associated strata and of the plant remains found therein, furnish the Professor with reasons for supporting the now almost universally received view, that the vegetable matter of which coal beds are formed was not transported, but remains where the plants originally grew. J. B.

The Transactions of the MIDLAND INSTITUTE of Mining, Civil, and Mechanical Engineers, for April, contain a paper by Mr C. E. Rhodes on Experiments on the LIME PROCESS OF COAL GETTING. The results of these experiments were disappointing, and, in the view of the writer of the Paper, shewed that in certain circumstances and in certain seams the lime process will not take the place of gunpowder. These conclusions are similar to those arrived at by the deputation from this Institute that examined the process at Shipley a year ago, and which were confirmed by the result of the experiments afterwards made by the Patentees at Earnock Colliery. J. B.

The Proceedings of the INSTITUTION OF MECHANICAL ENGINEERS for January contain an interesting and instructive Paper on the CONSTRUCTION OF THE ST. GOTHARD TUNNEL. A general review of the rocks passed through, with the difficulties encountered in getting the arching to withstand the pressure, is given, and useful hints as to the best method of excavating tunnels or large mines. The motive power of Turbines, and the action of water (at a high velocity) on iron and steel, are carefully treated.

The air compressors and boring machine which they worked are clearly explained by description and plates, and also the method adopted to cool the air during compression.

The temperature at various altitudes and depths, and the limit of temperature at

which men can work, are given, from observations made at the St. Gothard and other tunnels. The method adopted in excavating the St. Gothard and Arlberg Tunnels, with comparative cost of the two systems, forms an interesting part of the Paper.—W. C.

In view of the recently issued circular of the Home Secretary, suggesting the establishment of life-saving stations in mining districts where apparatus could be stored and men trained to their use, Mr Dickenson's Paper ON RESPIRATORS AND LAMPS FOR PENETRATING NOXIOUS GASES, in the MANCHESTER GEOLOGICAL SOCIETY'S TRANSACTIONS for April, affords timely information upon inventions apparently destined to play an important part in mine exploration after explosions.

Quoting from a report by Sir H. de la Beche and Dr. Lyon Playfair, dated 1846, the writer mentions a simple expedient which he has himself successfully used, namely, a respirator formed of a small bag of Glauber Salts and Lime which takes up the carbonic acid in the air. Several schemes for penetrating noxious gases with impunity, all dating within the past forty years, are described. They are all upon the principles applied to diving dresses, and only the most recent, that of Foster & Fleuss, seems to have passed beyond the stage of theoretic recommendation, so far as mining is concerned. That system has, however, stood the rough test of practical mine exploration on more than one occasion. Its great advantage over other systems is the complete independence of the wearer of all external aid. The apparatus, light and not inconveniently bulky, enables the wearer to penetrate places he could not reach did he depend upon long lengths of air-pipe, liable to damage in a thousand ways in mines.

The purpose of this paper is not to recommend any particular system, but rather to afford information upon the most important inventions, and this is done in a concise and simple style. The name of the author is sufficient guarantee that the paper will repay perusal. J. H.

The Transactions for the February Meeting of the MANCHESTER GEOLOGICAL SOCIETY contain a short paper by Mr Joseph Dickenson, entitled "NOTES ON SAFETY LAMPS." This paper, evidently put forward as introductory to Mr J. S. Green's paper aftermentioned, is purely historical; and throws a lurid light upon the condition of mine ventilation, even within living memory. Improved ventilation, somewhat paradoxically, necessitated improved safety lamps; and out of the earlier lamps was evolved the Mueseler, which was formerly—in Belgium, at least,—regarded as perfect. Now, however, it is found not quite reliable when explosive currents slant down upon it, (a fact which was evidently not generally known to the members present.) It is some modifications of this lamp, and also a method of testing on the bank, that Mr Green's paper describes.

Mr Green adopted the Mueseler Lamp at Celynen Colliery, Monmouthshire. The lamp he used was the true form of Mueseler, with the funnel projecting beneath the level of

the horizontal gauze about one inch, and less than that distance from the bottom of the funnel to the wick tube. He found that in certain conditions—after the wick had been extinguished by the explosive mixture—the gas continued to burn under the horizontal gauze, the flame revolving round the bottom of the funnel. This he remedied by the simple contrivance of placing a small tin projector outwards from the side of the funnel. With this, and the addition of a shield about 2 inches deep round the bottom of the gauze, and resting on the top of the ring above the glass, Mr Green claims that the lamp is "unexplodable under all probable conditions."

For a description of the testing apparatus, members are referred to the paper itself. Suffice it to say that it seems fairly adapted to reproduce the conditions as to air current ordinarily to be found underground. J. H.

DURATION OF THE COAL OF GREAT BRITAIN AND IRELAND, by G. C. Greenwell. Transactions of the NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS. Part 3, Volume XXXII., 1883, pp. 135-148.

In this paper exception is taken to the manner in which writers on this subject have hitherto dealt with the following elements of the question—the rate of annual increase in the production, the possibility of a concentrated production from the still unexhausted coal-fields by means of a corresponding increase in the local population, the migration of manufactures dependent on the adjacent coal area from exhausted to unexhausted areas, and the competition of foreign countries.

By an argument of *reductio ad absurdum* the mode of treatment of these points is combated, and the fallacy of the early failure of British coal-fields, due to the estimated enormous rate of increase in the annual production, is sought to be demonstrated.

Next, by taking the estimate of the Royal Coal Commission of 1871 as a basis of calculation the following table has been constructed :—

Coal Fields.	Coal in known Coalfields, Jan. 1, 1882.	Production in 1881 of Inspection District.		Years of Life.
	Tons.		Tons.	
Northumberland, Durham, and Cumberland, ...	8,582,588,808	1 & 2	15,830,720 21,539,809	230
Lancashire, Anglesey, Denbighshire, and Flintshire. . .	7,108,332,898	3 & 4	9,326,722 11,843,685	336
Midland, Leicestershire, Warwickshire, etc., ...	19,227,736,581	5 & 6	18,287,141 15,545,667	562
North and South Staffordshire and Cheshire, ...	5,757,060,356	7 & 8	6,473,900 10,058,670	349
Somerset, Gloucester, and South Wales, ...	36,515,584,123	9 & 10	8,318,821 16,008,525	1501
East and West Scotland. . .	9,649,009,254	11 & 12	14,148,880 6,674,175	463
Totals, ...	86,840,312,020		154,056,715	573

In addition to the above, a probable amount of coal underlying Permian and other formations at a less depth than 4000 feet is estimated at the present (1881) rate of supply (154,056,715 tons) to equal a life of 365 years. This quantity is, however, confined to the Midland Counties of England, and $\frac{2}{3}\frac{3}{0}$ths of it are in Yorkshire. J. H. R.

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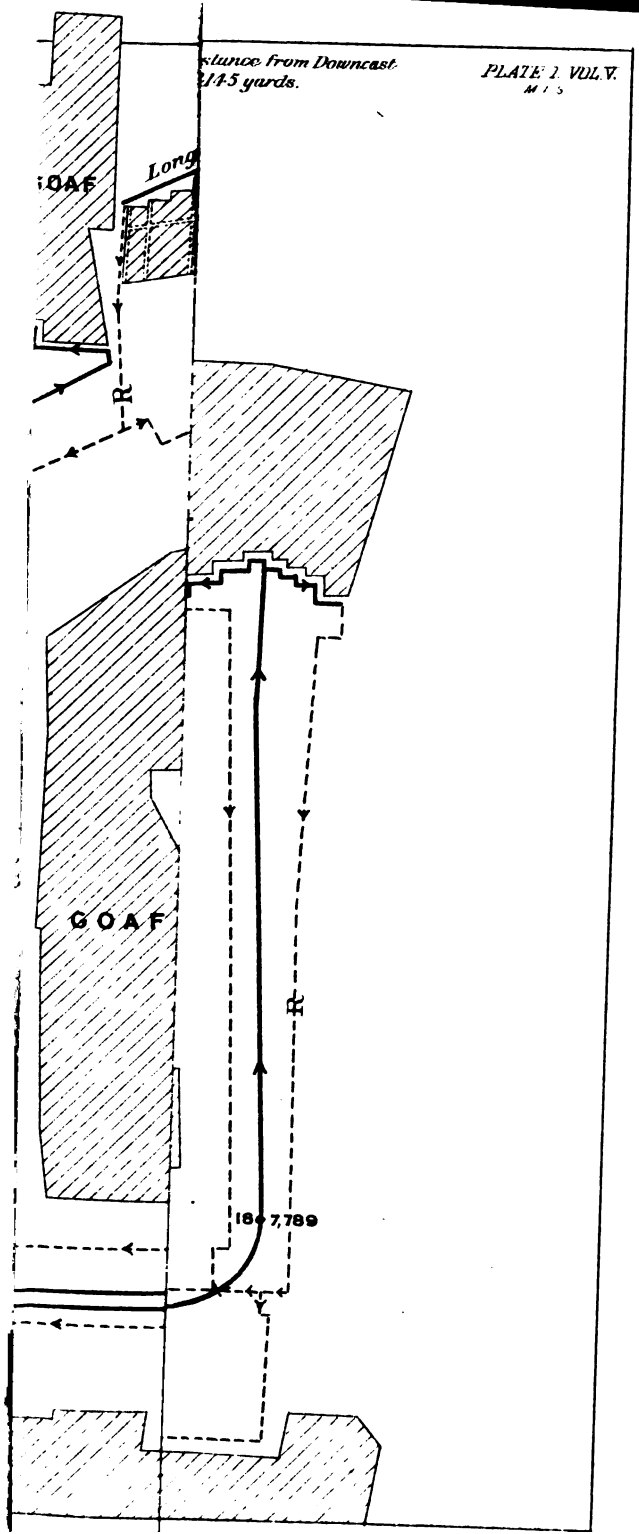
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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 5th JULY, 1883,

HELD IN THE ROOMS OF

THE CHRISTIAN INSTITUTE, GLASGOW.

JAMES M'CREATH, Esq., President, in the Chair.

Upwards of sixty members were present.

The minutes of the Special and General Meetings, held on 24th May, were read and confirmed.

The following gentlemen were elected by ballot, and admitted as Ordinary Members.

WILLIAM JAMES, Niddrie Collieries, Portobello.
JOHN WYLIE, Clifton Iron Works, Coatbridge.
JAMES HAMILTON, 97 North Frederick Street, Glasgow.
WILLIAM CLARK, 95 Bath Street, Glasgow.
JOHN GEMMELL, 96 New City Road, Glasgow.
ANDREW MUIR, Knightswood Colliery, Maryhill.
ALEXANDER W. WADDELL, Kinneil Iron Works, Bo'ness.
MICHAEL OSBOURNE, Blantyre Colliery, Blantyre.
ROBERT STEWART, 1 Dixon Street, Glasgow.
THOMAS PATERSON, 95 Bath Street, Glasgow.
ANDREW SPENCER, 160 Hope Street, Glasgow.
JOHN THOMSON HOWAT, Titwood Cottage, Pollokshaws.
DANIEL KEITH, Barrhead.
JOHN PICKERING, 154 West Regent Street, Glasgow.
ROBERT HOOD, 69 Buchanan Street, Glasgow.
ANDREW DARLING, Calderhead Colliery, Shotts.
ROBT. RITCHIE, Solsgirth Colliery, Kilsyth.
WM. MILLER, Townlands Colliery, Hamilton.
LOUIS HALBERSTADT, 123 Faubourg Poissonniere, Paris.
ALBERT H. SELIGMANN, 1 Victoria Crescent, Dowanhill, Glasgow.
ROBT. S. FORBES, 7 Leven Street, Pollokshields.

DISCUSSION OF MR CONNAL'S PAPER ON "SPONTANEOUS COMBUSTION OF COAL IN SHIPS."

Mr CONNAL said his paper was entirely confined to spontaneous combustion in Scotch coal-laden ships; but most of the gentlemen who had taken part in the discussion had dealt with both explosive gas—which was peculiar to English coal—and spontaneous combustion. As already explained, Scotch and English coals required different modes of treatment, as some of the latter class gave off explosive gas immediately after being put on board, and probably might at the same time contain all the agencies that generate spontaneous combustion as well, thus possessing two sources of danger; whereas, Scotch coal had only one, viz., liability, under certain conditions, to spontaneous combustion. He had never known a case where an explosion took place in a vessel newly laden with Scotch coal. Mr Smart had asked why the regulation in force as to the ventilation of mines should not be applicable to every ship's cargo that was liable to be affected by the generation of dangerous gases. The two cases were entirely different. It was an absolute necessity that "an adequate amount of ventilation shall be constantly produced to dilute and render harmless noxious gases in every mine," otherwise mines could never be worked, as human life could not exist in them under any other condition. On the other hand, as regards ventilation in Scotch coal-laden vessels, it was well known that, if only partial, it was practically useless, while most of the scientific men who had gone into the subject had condemned through ventilation as impracticable: hence his conviction that the entire exclusion of the air from the cargo, as proposed in his method, was the only practical means of averting danger from spontaneous combustion.

Mr RALPH MOORE said he could scarcely agree with Mr Connal that there was no danger from explosive gases in Scotch coal. There might not be danger to the same extent as in English coal, but there was danger. No doubt spontaneous combustion was the great thing they had to contend with, and they could not shut their eyes to the fact that it did exist. The importance of the subject could not be overestimated. The fact that they saw coal-laden

vessels wherein the cost of the coal itself did not form a third of the freight showed this, and the subject was one very well worthy of the Institute taking up and exhausting thoroughly. He had read the paper somewhat hurriedly, but he did not think that they need go into the question of what caused spontaneous combustion. He thought there were a few points which might be taken as axioms. For instance, they might say that combustion seldom occurred under thirty days. It occurred most readily in small coal, or dross; with pyrites, or shale, or dirt of a sulphurous nature mixed with it. That seemed to be the conclusion of every one. It occurred most readily among badly-cleaned coal and small coal, the smaller the coal the greater risk. It seldom occurred in bins of round coal placed on the surface; it never occurred in round coal on the surface where it was ventilated and in the open air. He believed it had never been known to occur in heaps of gas coal, nor in patent fuel made into bricks; and, so far as he knew, it never had occurred in solid coal. He would almost be inclined to put these down as axioms. It was clear when spontaneous combustion did occur that it drew air to increase the combustion. It was evident that the sooner the air was shut off the better. At the same time it was as evident that if the cargo never got beyond the normal temperature of the atmosphere, there would be no spontaneous combustion. He agreed with Mr Connal that the cargo should be hermetically sealed as far as possible. If the coals were loaded into boxes 8 or 10 feet square, and the boxes made air-tight and then put into the vessel, there would be no spontaneous combustion. He proposed to imitate this by filling the vessel with large lumps of coal, and so hermetically sealing the coal with the coal itself. Suppose they had a cubic foot of coal, there would be in

1	piece	1	foot cube	6	square feet of surface.	
8	pieces	6	ins.	„	12	„ „
64	„	3	„	„	24	„ „
1,728	„	1	„	„	72	„ „
13,824	„	½	„	„	144	„ „
110,592	„	¼	„	„	288	„ „
884,736	„	⅛	„	„	576	„ „

Now, he thought this was a very important matter, for if they had large coals they would certainly have less superficial area exposed, and there would be a simpler mode of ventilation. They would then have no difficulty in keeping the cargo of a vessel at the normal heat of the atmosphere. That being so, he had come to the conclusion that, with regard to their Scotch coal, which Mr Connal's paper dealt with, for vessels going more than a thirty-days' voyage they should only ship the hardest of the hard coal, and it should be hand-picked. A while ago, he had occasion to be at a Board of Trade meeting, and he gave utterance to these same opinions, and he had seen nothing in any of those papers or anywhere else to make him alter his opinion. In this way, they would expose the least extent of superficial area; they would have the whole interior of the block thoroughly hermetically sealed, and they would have a most simple means of ventilating the cargo. The question of expense was put to him. Well, no doubt it would cost more. The gentlemen there were quite able to estimate what would be the cost of the coal if they only had the round lumps. It would not be so much as people would think at first. There would also be the extra time of loading. He did not think that should enter into calculation. Why, in shipping bricks they would never dream of hurling them into the hold. Now, what were bricks? Their value was about 6s or 7s a ton. They would take the greatest care of bricks, and yet with a more valuable subject they took none at all. Mr Connal was entirely mistaken as to the date of the beginning of spontaneous combustion of coals. The earliest record, he thought, was about 1790, when a cargo of coals was shipped from Brora to some place in the north, and the vessel never reached its destination, having been burnt up. Mr Connal said he had had thirty years' experience. He (Mr Moore) had had a little more. But, thirty years ago, the whole output of Scotland was little more than 4,000,000 tons. A third went to the iron works; the greater portion of the rest to ordinary consumption. The shipping was a very small thing; he did not think the whole would be 500,000 tons. Now, it was a different matter, or at any rate the output was nearly six times what it was then.

Therefore, they might expect to hear of spontaneous combustion. Besides, he did not think Scotch coals went so far formerly.

Mr HILL said he was much obliged for the idea of the subdivision of the coal. It was evident that in the minute particles there must be a great many compartments of air, and it was quite in accordance with experience in regard to the milling of grain. It was well known that within the last few years there had been spontaneous combustion from the dust in mills, and it had also been found that it would explode; while there had been no spontaneous combustion from the cannel coal simply because it was in large lumps. It was very necessary something should be done towards having their ordinary coal shipped in great lumps, if they wished to reduce the number of cases of spontaneous combustion. It was a mere question of expense. That was a great drawback to almost every improvement; but he thought with Mr Moore that the additional expense could not be much. People getting the coal would be the better for it, and they might perhaps be willing to pay a little more for the coal.

Mr SMART said he quite agreed with Mr Moore that if they could get the coal shipped in lumps of a foot square, they would have no spontaneous combustion. If people got the coal all hand-picked, they would have no dirt and rubbish. He believed it could be done, but he questioned very much if, with their present shipments of coal, which had grown to such an enormous extent within the last few years, they could get a supply of round coal to meet the demand—more especially of hard coal, because hard coal was apparently going out. Soft coal was more in demand now for shipping, and there would be greater difficulty in having hand-picked coal with soft than with Splint coal. But (Mr Smart proceeded) I still advocate the ventilation of coal cargoes to prevent spontaneous combustion. I still maintain that a thorough system is necessary, and that the so-called method of ventilation hitherto adopted, which Mr Connal asserts is the primary cause of spontaneous combustion in coal cargoes, is no ventilation at all, and only has the tendency to fan the generating heat into active combustion. At page 25, Mr Connal demonstrates, in the example of the furnace, that a minimum quantity of air admitted

to a furnace has the effect of causing combustion to be rapid, which would be the effect of partial ventilation. It is well understood that the best method of extinguishing a fire of coal caused by spontaneous combustion is to expose the part to the cooling action of the atmosphere. Water has little effect, unless it is sufficient to completely drown the fire. Some of you must have noticed that spontaneously ignited bins of dross, or blaes, or ironstone burn best when it rains heavily. If ventilation is to be perfect, it must be thorough, and on a system similar to that which I described at our last meeting. Mr Connal stated that iron ships of 1000 to 2000 tons could be hermetically sealed. I have since made inquiries at practical shipbuilders, as well as captains of iron ships of this size, and they confirm my opinion that it is practically impossible for the general uses of a ship. The system of ensilage referred to by Mr Connal, and that by which meat is preserved in hermetically sealed vessels, are quite inapplicable to coal cargoes. In loading a ship with a full cargo of coal, not more than about one ton to every 50 cubic feet can be stowed, whereas a ton of solid coal is somewhere under 30 cubic feet, so that in every ship's hold loaded with coal, about 40 per cent. is atmospheric air. This proportion would be a considerable aid to spontaneous combustion although the hatches were firmly battened down. There is considerable uncertainty as to the causes of spontaneous combustion. There is no doubt it is due to the chemical action of some substances. Mr Connal asserts there can be no spontaneous combustion without iron pyrites. Perhaps he will explain how so many cargoes have taken fire with the Lanarkshire Splint coal, which is said to contain little or no iron pyrites, and how spontaneous combustion takes place in many other substances, both vegetable and mineral, with which there is no pyrites associated. The acknowledged seat of the fire is the spot under the hatchway, where the small coal mixed with the daugh and other rubbish is to be found, and where the iron pyrites, if existing, must be in an infinitesimal quantity, as it is a well known fact there is more pyrites in large lumps than in the small coal. The blaes or shale from the roof of the Splint coal, when stowed in quantity on the surface, has been frequently known to ignite spontaneously, as well as bins of the same material

brushed from the roof of ironstone workings. It is bituminous, and contains a proportion of oil, which has frequently been distilled from a burning bin and collected in pools on the surface. To this, along with the daugh of the pavement, which is more or less associated with all coal, and which when firmly packed in a ship's hold with small coal in a damp state may readily become oxidised, I attribute many of the fatalities due to the so-called spontaneous combustion of coal cargoes. In the paper before us by Mr Connal, he states there are two main causes that lead up to spontaneous combustion—viz., chemical combination and mechanical force. As to the first, it is plain that chemical action must take place before ignition. With regard to the second, it may be well to consider if mechanical force can possibly contribute in any way to aid spontaneous combustion. I am of opinion that the constant motion of a cargo of coal in a ship's hold would work on the angular fracture of the coal, and the friction caused thereby would reduce a portion of the small coal to powder, and consequently render it more liable to oxidation. I have also heard that it is generally after a storm, when the motion of the cargo and the attrition of the pieces have been greatest, that the first symptoms of the cargo heating are discovered. I consider this form of mechanical action may be considered as an aid to the primary cause.

Mr ROWAN said he did not quite understand how Mr Moore proposed to load the coal, and he must say he did not see the analogy between a cargo of coal and one of bricks, unless they could cut the coal by means of saws into cubes of regular form, in which form they might be packed into the vessel so as to prevent their moving. Mr Smart had spoken of the invariable effect of the motion of the cargo, coupled with the fact that the coal must be of irregular shape; and when they had small coal to any appreciable extent, whether it contained pyrites or not, they had one of the conditions necessary for spontaneous ignition. If they had carbonaceous matter in a fine state of division, the oxidation of that in itself was quite sufficient to generate heat; and when material such as coal contained volatile matters, spontaneous ignition was merely a question of time. He did not see any practical way of escaping the dangers of spontaneous combustion in coal cargoes

except the one of keeping the temperature as low as possible, and that could only be done by means of air,—by a thorough and efficient system of ventilation; because, even if it were possible to have the hold of the vessel hermetically sealed, there was, as Mr Smart had very forcibly pointed out, a sufficient quantity of air mixed with the coal cargo to generate the necessary heat,—to create a source of danger at any rate. Whether a very fierce fire could be started by it was another question. If it were possible to stow the coal, not by hermetically sealing it, but somewhat after Mr Moore's plan, he thought they would increase the cost to such an extent that they would find a very serious competition arise from those quarters where they loaded the coal under cheaper methods, and hit upon some practical and efficient way of keeping the cargo cool by ventilation. The following letter to the Board of Trade, which appeared in the *Glasgow Herald* of 23rd April last, might, he thought, with advantage be printed with this discussion, as it quoted some very important facts bearing on the subject:—

"Greenock, 10th April, 1883.

"The question of spontaneous combustion of coal cargoes on long voyages is of such vital importance to shipowners and underwriters, and has received so much attention from your Board, that the following information, which we have to-day received from the captain of our barque 'Inchgreen,' concerning his experience on a voyage from Dundee to San Francisco with a coal cargo, is our excuse for troubling you with a long letter. . . . The 'Inchgreen' sailed from Dundee on the evening of the 22nd April, 1881, with 1509 tons of Watson's Splint coal on board for cargo. These were shipped during fine weather, and so far as we can remember were perfectly dry when being loaded. The vessel has got two decks, 'tween decks being laid, with the exception of a middle space of three feet, running right fore and aft, for which there are hatches, but with coal cargoes these are not put on. With this particular cargo the coals were about two feet from the main deck from the after hatch to the fore hatch, sloping down at both ends, leaving a free space of about 40 feet aft, and about the same forward on the 'tween decks. The ship is very well ventilated, having two bellmouth ventilators on forecastle—the forward one 7 in. diameter at deck and 14 in. at bellmouth, the after 9½ in. diameter at deck and 16½ in. at bellmouth, ventilating both lower holds and 'tween decks; a ventilator of 11 ft. by 9 in. through the house on deck between fore and main hatches for the 'tween decks only; another, three feet square, ventilating lower holds and 'tween decks abaft mainmast; another, two and a half feet square, ventilating 'tween decks about

twelve feet from after collision bulkhead. . . . On the 12th of May, after being three weeks out from Dundee, in lat. 36 14 N., long. 19 W., Captain Miller discovered that the coals were heating, and that there was a dense vapour rising from them, which the ventilation then in use did not seem capable of carrying off. He caused a passage to be dug from the main hatch forward, and, with the view of improving the ventilation, cut a circular opening in one of the fore hatches, into which he shifted one of the forward ventilators, erecting a small windmill at its mouth, he believing this would draw off the vapour and heated gases much more rapidly than by the ordinary action of the ventilators. The coals at this time had become so heated that it was almost impossible to stand on them, and Captain Miller was very apprehensive of the safety of his ship. Soon after the application of the windmill an improvement was observed which daily continued. until at the end of three weeks there was no sign of heat in the holds, the coals continuing cool until the termination of the voyage at San Francisco on the 2nd October—162 days from Dundee. At that particular time, nearly all the ships sailing from Dundee and arriving at San Francisco were more or less affected by fire in their cargoes. So far as we at present know, the 'Dunottar Castle,' 'Caitlock,' and 'Traveller,' had their cargoes on fire, and the 'British Sovereign,' which succeeded the 'Inchgreen' at the coal crane, has never been heard of. We think it probable that the 'Inchgreen's' immunity from fire is owing to the simple contrivance arranged by Captain Miller, and we bring the matter before you with the desire of its being made known to shipowners and shipmasters loading similar cargoes.—Yours faithfully,

"WM. LINDSAY & Co."

Mr MOORE said Mr Rowan would see that he merely hinted that while an article of the value of 7s a ton was very carefully loaded in the shipping of bricks, an article of greater value, viz., coal, was tumbled into the vessel with no care whatever. That was all he meant. But still, with regard to the cost of loading it, or the cost of the coal, he had not gone into that, but whatever be the cost he thought it was imperative that under-writers, or people insuring vessels, should see that every means were taken in shipping the articles that they would reach their destination safely. Whether the method he suggested was the best or not, of course he did not pretend to say, but he really did think that a little more care should be taken in ascertaining the quality of the coal and the mode in which it had been shipped before it was insured. Mr Smart had remarked on the very inferior coal that was shipped. If it could be shown that that coal was more liable to spontaneous combustion than better coal, he thought it was their

duty as an Institute to say so, so that under-writers, or other parties interested, should know the real state of matters.

Mr JOHNSTONE said that a solution of the difficulty might be found in the extraction of the ammonia from the coal. If suitable retorts could be made so as to get off the lighter hydro-carbons, ammonia and sulphur, the remainder, including the fixed carbon and heavy hydro-carbons, could be compressed into suitable cubes, which would save much room in shipping. It would also make a better bunker and steam coal. The only question was one of economy; but, by improved apparatus, the ammonia extracted should fully pay the outlay.

Mr SMART said the President very justly brought under their notice at last meeting a statement in the Royal Commissioners' report of an analysis by Professor Ferguson of Glasgow University, that there was 12 per cent. of iron pyrites in the Ell coal of the Hamilton district. He had looked up the report since, and found that Professor Ferguson had these from samples before him:—First, from the Hamilton Coal Coy.; secondly, from John Watson; thirdly, Roughrigg; and fourthly, Russell's Splint. In giving the analysis, they had simply columns for ash, sulphur, and iron pyrites, and, in the Ell coal of Hamilton, they quoted the sulphur as high as 14.66 per cent. Now, he had got an analysis of the first of these coals, made by Mr Tatlock just two years after this analysis by Mr Ferguson, and the sulphur contained in it was stated at .95, showing there must be some egregious error somewhere. Even the ash which was stated by Professor Ferguson at 19.50, Mr Tatlock showed was ·91; and they knew quite well that the one was a much nearer approximation to the truth than the other.

Mr HASTIE said he supplied Mr Tatlock with the sample of the Hamilton Ell coal.

The PRESIDENT—And it was a fair sample of Hamilton Ell coal from top to bottom?

Mr HASTIE—It was.

Mr COWAN—Could you tell us how much carbon was in that coal?

Mr SMART—Professor Ferguson does not state the carbon. Mr Tatlock gives it at 52·80. There is 19.50 of ash, which would leave about 39 of carbon.

Mr COWAN—There has evidently been some mistake in placing the points.

Mr SMART—They are published, and that in a very valuable report.

Mr DRINNAN said the opinions be held with respect to this paper he expressed mainly at last meeting. He agreed pretty much with Mr Smart with regard to what he then said, and had now supported, with the exception of what he said as to blaes. In view of the importance of the paper, he thought it was well it should be carefully treated, and the more carefully he read it, the more difficulty he found in believing that Mr Connal was really their friend in this matter. At page 26, about the middle of the page, Mr Connal said no matter what might be the cause of the ship being lost, the underwriters put it down to spontaneous combustion, and that this was an absurd method requiring immediate redress. He thought most of the members would agree with Mr Connal as to this, but at the top of page 25, Mr Connal himself said that the English process of ventilation carried out in ships laden with Scotch coal had, in his opinion, been the source of all the disasters which had befallen such vessels.

Mr COWAN said he was inclined to believe, from what he had seen in one or two places, that it was practically impossible to seal a ship hermetically; and, secondly, that the only practical way to prevent spontaneous combustion was to keep down the temperature by passing strong currents of air through the mass. Spontaneous combustion may be said to be intensified oxidation; and, of course, if the coal were subdivided minutely a greater surface was exposed to the action of oxygen, and, if it were not carried away by air currents, the conditions favourable to spontaneous combustion would be intensified, and the coal sooner or later would burst into flame. With Cardiff coal he had seen many cases where it was not long unshipped till the whole bin was in process of combustion. This coal, as they were aware, was very friable, hence much "gum" or "duff" was produced by the attrition due to the motion of the ship, land transit, and handling. The same Cardiff coal when made into "briquettes" or patent fuel he had never known to ignite spontaneously.

Where a good deal of carbonaceous matter was associated with pyrites, as for example, on the edges or "Salabanda" of pyrites deposits, the mixture, when first exposed, was apt to ignite spontaneously. This might be used as an argument in favour of hermetically sealing; but on the other hand the only way he found practicable to prevent ignition after the fire had been extinguished was by liberal ventilation. The conditions which led to spontaneous combustion were pretty well known, but the causes were not so well known, unless it were taken generally that a supply of oxygen operating in the combustible mass was that cause, and if so, it was only by dilution of the oxygen that it could be prevented.

The PRESIDENT, remarking that Mr Cowan, he thought, had seen the Scotch, North of England, and Welsh coal, after a lengthened sea voyage, said that possibly he would favour them with some account of their several liability to spontaneous combustion.

Mr COWAN replied that for seven years he had to deal with large quantities of coal of the several kinds mentioned (20,000 to 30,000 tons per annum) in a foreign country, and, of course, all of this coal was sea-borne. The Cardiff coal after discharge was most liable to spontaneous combustion. The other coals were not so liable. He had never seen a case of Scotch or English coal igniting spontaneously in the bin, but had heard of it.

The PRESIDENT—Was it Welsh coal that generally took fire?

Mr COWAN said it was Cardiff coal he had in his mind. It was the purest coal they knew; but when it got wet, perhaps after a week or a fortnight the germs of spontaneous combustion would make themselves apparent. It was a great trial to the manager of a large establishment abroad to see his stock of coal burst into flame in a single night as once or twice happened. To remedy this he had a suitable coal depot formed. It consisted of a bench, about the height of the bottom of an ordinary railway truck, built by open ruble stone work, and culverts running across every five metres. The top of the bench on which the coal was stored was divided throughout its length by walls, so as in a manner not to have "all the eggs in one basket." Thus perfect ventilation was secured in addition to convenience for re-

loading. On this bench were stored Cardiff, Scotch, and North of England coals and coke; and during five years after its construction that it was under his observation not a single trace of spontaneous combustion was ever apparent.

Mr CONNAL briefly reviewed the discussion, and, in reference to what had been said by the advocates of large coal, stated that if shipped in the same mode as at present as much dross would be made as would cause spontaneous combustion. As to Mr Smart's statement that it would be impossible to keep a ship hermetically sealed, he thought it would be a great pity were this to go abroad uncontradicted, because it could be done.

The PRESIDENT—The remarks I intended to make have been, to a large extent, anticipated by those of Mr Ralph Moore. The cause of spontaneous combustion has, in the discussion, been attributed to three sources:—*First*—The oxidation of pyrites contained in, or mixed with, the coal. *Secondly*—The oxidation of very finely divided coal. *Thirdly*—The oxidation of bituminous rubbish mixed with the coal. It is evident that, apart from the danger of spontaneous combustion, it would be for the interest of all concerned that as little as possible of all three should be shipped for long voyages; as an equal rate of freight must be paid for them as for good round coal, the value of which much exceeds even that of clean coal gum; and those members who in their respective departments of producing, or of selling, or shipping the coal give strict attention to this, will probably do more immediate good in reducing the evil of spontaneous combustion on board ships than by devising means to convey safely over sea such mixtures as Mr Smart tells us are now put on board. We have had four schemes put before us for effecting the safe conveyance of coal, viz.:—That advocated by Mr Connal in the paper under review, and those advocated severally by Mr Thomas Rowan, Mr Smart, and Mr Moore. The first is simply to make the hold air-tight, and allow any excess of fire-damp accumulating to escape from time to time. Mr Rowan's scheme assumes that it is impracticable to form a perfectly air-tight hold; and he would insert numerous tubes into the cargo for ascertaining the temperature periodically, and he would have abstractors for carrying off the heated products of incipient combustion. To

draw off the products of incipient combustion without drawing air to where it might do mischief would, I fear, be a very difficult operation. Where there is incipient combustion there must be some air getting admission; and to draw off the products of the combustion would be accompanied by the admission of more air, producing, to a certain extent, that partial ventilation which he otherwise deprecates. Mr Smart's scheme is to keep the cargo cool by currents of air. No doubt this could be done if there be enough of cool air passing, and the layers of coal between the currents thin enough; but as to whether this would be found practicable in the holds of vessels, I have not sufficient knowledge of shipping to judge. It has been stated as an objection to Mr Moore's scheme of shipping only large coal and loading by hand, that a market could not be found for the small coal separated, and that the large coal would, by the rolling of the ship, be ground small. It need not be that only the very large lumps be shipped, but, say, such as would pass over a three or four inch screen. The attrition by the rolling of the vessel could not, I suppose, produce anything like the same surface exposure as if the small coal had been shipped with the round; and that the ship would not thereby be endangered, as it is now, by the small coal lodging at the hatches through tipping, seems almost certain from the evidence given in the Royal Commissioners' report as to the comparative safety of cargoes loaded by barrows over those loaded from tips.

Before sitting down, the President proposed a hearty vote of thanks to Mr Connal for his paper, which was duly accorded.

DISCUSSION OF MR R. T. MOORE'S PAPER ON "FRENCH VIEWS OF ENGLISH MINING."

On the PRESIDENT'S suggestion, as it was now approaching the hour for adjourning to visit the offices of the Edison Electric Light Coy., the discussion of this valuable and important paper was postponed till next meeting.

VISIT TO EDISON'S ELECTRIC LIGHTING ESTABLISHMENT.

BY arrangement, the members of the Institute proceeded to the offices of the Edison Electric Light Coy. (Limited), 104 West George Street, where they were received by Mr Grant. A variety of lamps were burning, and brilliantly illuminated the premises. Mr Grant first exhibited the "Invalid Lamp," which, he said, would be suitable for use in the mine. He explained that it could be carried in the pocket, any amount of electricity which it contained being perfectly harmless. They could also go in search of fire-damp with it. While it would be impossible to explode the lamp, it might be broken; and they were anxious to put it to the test to ascertain if it would expire more quickly than fire-damp would ignite.

Mr MOORE said he thought the first point was to ascertain what was the cost of the light as compared with that of an ordinary collier's lamp.

Mr GRANT said there was no possible comparison betwixt the two in respect of price. This was a sixteen candle light; eight candles was their lowest.

Mr MOORE—What is the cost of eight candles per day?

Mr GRANT said they had had no experience in fitting up these lamps in mines; but a vessel left the Clyde for Australia with 150 of those lamps, and, for 47 days during which they were burning, only eight were broken—the price being 28s, or 3s 6d each lamp.

Mr MOORE asked what would be the lowest sum that would be sunk in an arrangement to give say fifty lamps?

Mr GRANT said they had nothing so small as that. The lowest was a sixty-lamp machine, and the cost would be about £300. He asked if they were satisfied as to the safety of the lamp?

Mr MOORE replied that there was nothing in the safety of the lamp. Like others, it must be prevented from igniting gas. Mr Moore, in further conversation, suggested (and Mr Gilchrist, Earnock Colliery, agreed with him) that if the wires were broken by a fall from the roof or otherwise, danger might arise in the

event of an arc being formed through the positive and negative wires coming into contact, and igniting the fine dust, rubbish, or surrounding coal.

This point was accordingly put to the test, first near the dynamo machine, and next with the first lamp on the circuit, with the result that the general opinion was that this would be a source of danger.

Mr MOORE proposed a vote of thanks to Mr Grant for his kindness in showing the lamps and experiments, which was heartily accorded.

Mr GRANT, in returning thanks, promised after the summer months were over to supply an estimate of the cost of lighting a pit for reproduction in the Transactions.

The company then left.

VISIT TO MESSRS NORMAN & SON'S ESTABLISHMENT.

THE electrical establishment in Argyle Street of Messrs Norman & Son was next visited. Mr Musgrove, the senior partner, heartily received the members, and introduced his partner and manager, Mr M'Whirter, who proceeded to explain the various lamps and apparatus on exhibition.

CROMPTON'S E DIFFERENTIAL LAMP.—In this lamp the mechanism is contained in a metal case above the carbons, and therefore does not affect the light by throwing shadows, &c. When the current is switched on, the carbons being in contact, the negative rod is pulled down by means of an armature attached to the same, moving above an electro-magnet through which the main current passes. This downward movement is just sufficient to establish an arc of proper length; and, so long as the arc remains of this length, no further movement takes place within the lamp. The consumption of carbon, however, causes the arc to become longer; and, to prevent this, the controlling mechanism is arranged thus:—On the top of the lamp case and outside of the same is fixed a small electro-magnet, wound with very fine

wire, having a resistance of about 200 ohms; and the two ends of this wire are connected, one to the positive and the other to the negative terminal, thus allowing a small current to pass through these coils without going through the carbons, and which current is proportional to the electro-motive force in the arc. The function of this electro-magnet is to lift a small brake (against an opposing spring by means of its armature), which presses upon the periphery of the last wheel in the train of mechanism which controls the descent of the positive rod, by means of a rack cut on the same, and which gears into the first wheel in the train. When this brake is lifted off, the rod is free to move down slowly, and this would continue going on until the carbons would either run together or the brake be applied. The method of control is worked thus :—On the lamp at first striking an arc, the current passing through the above electro-magnet is not sufficient to overcome the tension of the spring, which therefore keeps the brake applied. As the arc slowly increases in length, the electro-motive force between the two carbons increases slowly, with the result that more current must pass through the electro-magnet. This goes on until the current passing is sufficient to lift a small armature and allow the lamp to feed down, one or two turns of the brake being sufficient to again establish the proper length of arc, when the brake is at once applied: and as each turn of the brake wheel is only equal to ·1 m/m (about $\frac{4}{1000}$ of an inch), the feeding is almost continuous and a steady light is thereby insured. Owing to the negative rod in this lamp being a fixture, the whole of the feeding requires to be done by the positive rod, with the result that the arc gradually descends as the carbons burn away. This prevents the employment of this lamp for any purpose where a projected beam of light is required. Further, the lamp only burns about six hours between renewals. This is the form of lamp we are now using so successfully in the lighting of St. Enoch Railway Station. A diagram shewing the mechanism of the lamp will be found at Vol. IV., part 12, page 350 of your Transactions.

CROMPTON'S G[1] LAMP.—The next lamp we have to call your attention to is that known as Crompton's G[1]. In this lamp

the duration of burning is increased to twelve hours; and the negative carbon being arranged to rise at half the speed of the positive a focus-keeping lamp is obtained. This is carried out by means of a very simple arrangement of cord and pulleys. One new feature in this lamp is the method of striking the arc. In this instance an armature placed in the case of the lamp lifts the positive rod and the whole of the controlling mechanism bodily up to the height required for giving the proper distance between the carbons. The regulating arrangements are identical with those described in the E differential lamp. This lamp we are using exclusively for lighting the Barrow Docks.

CRABBE LAMP.—The Crabbe Lamp, which we now come to, is a modification of the last, the two lamps externally being very much alike. In this lamp, however, the controlling arrangements are very different. The positive carbon holder is suspended from a cord which passes over a pulley at the top of the lamp, then round another pulley, from which the controlling mechanism is hung; thence down one of the side rods and around another pulley at the bottom of the negative rod; from under the controlling mechanism hangs a hollow iron cylinder or core which works inside of a long solenoid. The upper half of this solenoid is wound with a long coil of fine wire, having a resistance of 200 ohms, and this coil is connected to the two terminals of the lamp. The lower half of the solenoid is wound with a heavy wire through which the whole of the current feeding the lamp passes. Under the last wheel in the train of mechanism hangs a brake which, on being pressed against the periphery of this wheel, prevents the carbons from feeding together. The action of the lamp is thus:—When the current is switched on it passes round the lower half of the solenoid, drawing down the core which simultaneously raises both carbons; but, as the positive carbon is pulled up at double the speed of the negative carbon, an arc is established between the points. So long as this remains constant, the current passing through the fine wire coil is unable to move the core upwards within the solenoid, which it is constantly endeavouring to do. Owing, however, to the lengthening of the arc, the current gradually

increases in the fine wire coil, and at last the core rises a little with the mechanism above it. The result is, that the brake is lifted away from a detent which applies it, and being allowed to fall from the rim of the brake wheel, the mechanism allows the carbons to feed together until the normal conditions are again established. The working of this lamp is exceedingly regular, and, as the arc is not fixed, but free to lengthen and shorten to suit any variations of current, the light is remarkably steady; and as the movement of the arc is only about one fourth of the movement of the core, the latter has a considerable range through which it can work without causing violent movement at the carbons. This lamp is used for the lighting of Messrs Pullar & Sons' New Dye Works, Perth.

THE LUMLEY LAMP, which we use to-night for the photographic work, is rather different from any of the others in its action. The lamp on being trimmed keeps the carbons apart by reason of a spring which draws the brake in contact with the last wheel of the train of mechanism. This brake is fixed at one end of a lever pivoted at the centre, the other end carrying an iron armature, and reaching above an electro-magnet which is wound with a coil of high resistance. To work these lamps it is necessary to use a shunt dynamo, or at least a dynamo which is able to generate a large electro-motive force, with the main circuit open. Such a dynamo is able on first starting to send a considerable current through the electro-magnets, controlling the brakes which are at once released from the brake wheels, and the weight of the positive rods causes the same to descend, making contact between the carbons. On this taking place, the negative rod is at once drawn down by means of a current passing through an electro-magnet in the base of the lamp which gives the proper length of arc. At the same instant the electro-motive force at the two ends of the shunt coil falls considerably, with the result that the armature is released and the brake at once applied, which prevents the positive rod following the negative downwards. The brake wheel is made in the same form as the escape wheel of an ordinary clock train, and this, by reason of the teeth, gives very great holding power to the brake, preventing any slipping

while the lamp is at work. The feed is very similar to that in Crompton's E differential lamp; and, on the whole, this lamp, which has just been introduced, promises very well.

THE WESTON LAMP.—This lamp is of a rather different type, being entirely without mechanism to regulate the feed. In this lamp, the arc is struck by means of an electro-magnet placed horizontally, but with the poles in a vertical plane, which attracts the armature upwards, from the lower end of which a clutch hangs which grips the positive rod on being lifted by the armature. From one end of the clutch there is a projection or tail-piece bending slightly downwards. So long as this projection is above the base of the lamp, there is no movement of the positive rod through the clutch; but, on the tail of the clutch making contact with the base, the positive rod is free to move downwards. The regulation of the lamp is carried out thus:—The electro-magnet, before alluded to, is wound with two coils of wire, one being in the main circuit, and the other connected, in the manner before described, between the two terminals of the lamp, and having a high resistance. On the current passing through the lamp, the main coil, being the most powerful, at once separates the carbons by an upward movement of the armature. This upward movement is resisted by a shunt coil, and a state of equilibrium is established until the electro-motive force increasing in the shunt coil is sufficient to cause the armature to drop; the clutch being released from the positive rod, the latter is free to descend. This, however, takes place so rapidly that the downward movement is very little and occurs often. The Weston lamp is very simple in construction, and is not liable to get out of order. It, however, gives trouble on account of the clutch failing to do its work as well as it should, the consequence being that the carbons occasionally drop right into contact.

INCANDESCENT LAMPS.—In the arrangement of incandescents which you see carried out in the drawing-room, you will notice that the old plan of placing the lights in groups or clusters, as introduced for gas lighting, has been entirely abandoned, and the plan adopted of a regular distribution of lights over the entire area required to be lighted. Mr Musgrove's reason for this

innovation was, that as the light decreases as the square of the distance, the less concentration where small lights are used the more regular the lighting throughout. Another improvement is the total absence of shadows, and, further, the abandonment of the use of expensive fittings for supporting the lights. In the dining-room the same ideas have been kept in view ; but the ceiling is intended to represent a house already built, and where it would entail a large expenditure to run the electric leads between the floor and the ceiling so as to get them out of sight. This difficulty is met by making the leads form part of a design running across the ceiling, and from which the lamps are suspended. Arrangements have been made for carrying out these designs in the most elaborate form. The incandescent lights, above alluded to, are worked, as well as the other incandescent lights throughout our offices, by means of a set of FAURE-SELLON-VOLCKMAR ACCUMULATORS, which have been in daily use since January last. These accumulators were also used for driving a motor, giving power to our lathes, &c. In the experiment which we now show on the transmission of power, the arrangement is as follows: —In our engine-room below, there is a Burgin dynamo giving current to a Burgin dynamo in our offices, the latter being coupled by means of belting to a shunt dynamo which is used to charge the accumulators lighting the various rooms. The arrangement as shewn is not of course intended to be economical, but simply to show, on a large scale, the transmission and accumulation of energy. This dynamo would require to run for ten hours to charge the accumulators fully, and these in their turn would keep about 25 Swan lamps of 20 candle power each going for 10 hours.

The large light of 20,000 candle power hanging outside of our premises is worked by a lamp of the same type as Crompton's E differential, the power being supplied from one of Crompton's Compound Shunt Burgins, giving a current of 70 ampères.

The whole of the electric light machinery in our premises is worked by means of a compound engine by Marshall & Son of Gainsborough, which type of engine does its work both efficiently and economically.

The collection of measuring instruments exhibited are those

we have in daily use, consisting of Dispersion Photometer, Reflecting Galvanometer combined bridge and resistance Instrument, Astatic Galvanometer, Metre Bridge, Current and Volt Meters, &c.

The party were photographed in groups by means of the electric light; and before leaving, the President thanked Mr Musgrove for the interesting exhibition he had brought within the notice of the Institute, and hoped it would lead to business.

Mr MUSGROVE replied, and the proceedings terminated.

The following specification and estimate for lighting a colliery, either above or below ground, with incandescent lamps were afterwards prepared by Messrs Norman & Son, from particulars furnished by Mr Gilchrist, Earnock Colliery :—

For the supply and erection of Dynamo Machine on the most approved principles, to work 100 twenty-candle-power incandescent lamps, so that any number of the lights may be used, from 1 to 100, the machine to be fixed on sliding tension frame to allow for variations in belts; one ammeter; one voltmeter; one safety catch, and one main switch—the whole complete for the sum of - - - - - - - - - - £175.

For the supply and erection of Dynamo Machine to work 60 lights, so that any number can be used from 1 to 60, including ammeter, voltmeter, safety catch, and main switch—the whole complete for the sum of - - - - - - - £130.

Main Lead, suitable for carrying current for 100 lights, including out and in leads up to distances not exceeding 400 yards, for - - - - - - - - - - 5s per yard.

Main Lead, suitable for carrying current for 60 lights, out and in, up to distances not exceeding 400 yards, - - 4s per yard.

Leads for carrying current for 30 lights, out and in, up to distances not exceeding 400 yards, at - - 2s 6d per yard.

Leads for carrying current for 15 lights, out and in, 2s per yd.

Branch leads, for one or two lights, - - - 1s per yard.

These prices include the fitting up of the leads wherever required, but do not include any protecting casing, which would probably be found necessary both in the shaft and in some parts

of the workings. Wherever this is required, the same to be supplied and fitted up by the colliery proprietors free of cost to the contractor. The leads to be of highest conductivity copper, having a conductivity of not less than 96 % pure copper. The insulation to be of best vulcanized rubber, and protected externally by tapes, and to have an insulation resistance of not less than 500 megohms per mile.

Brackets with reflectors having protecting cage to prevent damage to the lamp, including lamp, holder, switch, and safety catch, fitted complete, - - - - - - - 16s each.

Hanging lantern, suitable for use in the workings, and so arranged that it can either be carried or hung up, including lamp, holder, safety catch, and 10 yards flexible lead, - - 16s each.

The same lantern, &c., but fitted up with small drum attachment, suitable for carrying 100 yards of conductor, and so arranged that the conductor can either be uncoiled to the whole of the distance or coiled up without in any way interfering with the burning of the lamp—the whole complete, - - 30s each.

Main switches for current up to 20 lamps, - - 10s each.

The cost for the complete installation is not quoted on account of the difficulty in knowing the exact length of leads that might be required; but the information will enable the cost of proposed installations to be arrived at, under whatever circumstances they may be.

The power for driving the dynamo machine is understood to be supplied by the colliery proprietor.

NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES

The Transactions of the AMERICAN SOCIETY OF CIVIL ENGINEERS for April, 1883, contain a paper by Mr Hamilton Smith, jr., M. Am. Soc. C.E., on the FLOW OF WATER THROUGH PIPES. It is a record of 83 experiments, 71 of which were made by the author of the paper, on the resistance to the flow of water by pipes of different diameter and of different materials.

The formula for the velocity of flow of water through pipes was taken as

$$v = m\sqrt{\frac{dh^1}{l}}$$

where v = velocity in feet per second,
d = mean diameter,
h^1 = effective head,
l = length of pipe,
m = variable coefficient,

The experiments were made in order to find the value of this variable coefficient m, and this the writer found varied with—

First—The character of the interior or wetted surface, being very low, with small, rough pipes.

Secondly—It increases with the velocity with smooth pipes.

Thirdly—It increases with the diameter.

It is shown that m varies from 36 for a 1 inch gas pipe, with a velocity of 1·195 feet per second, to 67 for a 26 inch malleable iron pipe with a velocity of 12·60 feet per second.

The Number also contains a discussion on a paper on THE INCREASED EFFICIENCY OF RAILWAYS FOR THE TRANSPORTATION OF FREIGHT by William P. Shinn, read Nov., 1882, vol. XI. page 5.

In the course of this discussion Mr J. B. Jervis noted the improvements in the road-beds which had taken place in American Railways and the benefits to be derived from increasing the size of the waggons so as to lessen the proportion of the useless load He also notes that the gradients are much steeper now than formerly. In 1824 the tractile power of adhesion to the rail was set down at $\frac{1}{2\frac{1}{4}}$, and when the Liverpool and Manchester Railway was made it was considered necessary to put down stationary engines when the gradient was steeper than 1 in 100. In 1828, $\frac{1}{7}$ was assumed as the coefficient of adhesion, in 1846 $\frac{1}{9}$, and it would now probably be taken at $\frac{1}{6}$. Mr O. Chanute said that they derived a great benefit in the Erie Railway from altering their locomotives so as to make them draw heavier trains. In 1874 the average load was 106 tons a train. In 1876 heavier engines were put on, drawing 228 tons instead of 106, and the expenses of doing the freight traffic were reduced from ·479d per ton per mile to ·263d. The delay in the traffic of goods was mentioned, and it was noted that a run of 50 miles per day was a fair average for a goods truck. R. T. M.

Among the more interesting papers in the American ENGINEERING AND MINING JOURNAL for May and June, 1883, the following may be noted:—

In No. 20.—The HENDERSON GAS FURNACE, with descriptive drawings. It is

claimed for this Furnace that it combines a number of details looking towards as complete a utilization of the fuel as possible, together with the rapid generation of the highest heats practically required.

In No. 21.—The BROOKLYN BRIDGE: A brief review of its history, and a few data on the method of construction, with a note of the dimensions of the principal parts.

In No. 22.—Experiments on the KOEPE WINDING SYSTEM, in which hoisting drums are dispensed with, the rope being carried round a simple pulley to the sheaves, a cage being attached to each end and the bottom of both being connected with a tail rope. The experiments, which are by Herr Baumann, are to ascertain the amount of friction of the rope running on wood, on leather-covered wood, and on cast-iron.

MINE HAULAGE, with comparison of the cost by mule-power locomotive, endless rope, and tail rope; from information compiled by Thomas K. Adams, Inspector of the Third Bituminous District of Pa.

In No. 25.—A description with drawings of the DEAN INDEPENDENT CONDENSING APPARATUS.

Nos. 21, 22, and 23 also contain a series of papers on the utilization of BY-PRODUCTS IN THE MANUFACTURE OF COKE, in which the Carvés, the Otto, the Aitken, and the Jameson systems are described and illustrated. J. B.

In ENGINEERING for May and June, especially Nos. 903, 909, 910, and 911, a large proportion of the space is occupied by descriptions and illustrations of various systems of ELECTRIC LIGHTING and notes indicating the progress being made in the manufacture of electrical appliances and the adapting of these to different kinds of work. The following papers and descriptive articles on miscellaneous subjects may also be noticed:—

In No. 905.—THE LANCASTER SWIVEL JOINT, serviceable in cases where a movable machine is driven from a stationary boiler.

THE WASS FEED-WATER HEATER, for extracting grease, air and mud from the feed water of steam boilers.

In No. 908.—The MAS GOVERNOR.

In No. 911.—WIRE ROPE TRAMWAYS in American cities, chiefly Chicago.

In No. 912.—THE TOOLS OF THE PYRAMID BUILDERS.

THE SHARPE-PALMER VERTICAL BOILER.

In No. 913.—BLAKE'S COMPOUND STEAM PUMP WITH CONDENSER.

THE CHANNEL TUNNEL.

Nos. 912 and 913 contain also a description with drawings of APPARATUS FOR BURNING LIQUID FUEL; and in

No. 914 a beginning is made with a description of Various exhibits at the Engineering and Metal Trades' Exhibition in the Agricultural Hall. J. B.

SAFE LIGHTING OF COLLIERIES. A paper by Mr W. E. Teale, in the Transactions for May, 1883, of the MIDLAND INSTITUTE OF MINING CIVIL AND MECHANICAL ENGINEERS, compares certain safety lamps,—in their construction, light-giving properties, arrangements for locking, behaviour in currents of air and mixtures of gas, &c.,—with Mr Teale's Mueseler Protector Lamp, the conclusion arrived at being that the Protector is the best of them. J. B.

SOUTH WALES INSTITUTE OF ENGINEERS.—VOL. XIII., No. 4.

BUNNING'S IMPROVED WATER LEVEL, by Mr Charles Bunning.—This level, which has already been under the notice of this Institute,—see Vol. III., p. 213,—consists of two graduated staves, each with a glass tube, having a stop-cock at the foot, inserted into it. The tubes are connected together at the bottom by a flexible rubber pipe from ten to twenty yards long. This pipe and one of the glass tubes being filled with water and the stop-cocks opened, the difference of the readings of the height of the water will be the difference of level of any two points on which the staves may be placed. Greater range may be obtained by making the staves to slide in frames. Mr Bunning claims for it simplicity, accuracy, and speed; and, particularly, that levels may be taken around or over an obstacle.

UNDERGROUND HAULAGE, by Mr David Evans.—He had a self-acting incline, lowering 450 tons per day, worked with a drum, and the ropes lasted five years; but where he employed the clip pulley, the ropes lasted only about two years. He found that for dook roads a fall of 1 in 18 was required for the hutches to take back the rope. He gives a plan and section of a Tail-Rope Road, at No. 1 Pit, Ferndale Colliery, worked by a pair of 18 inch compressed-air engines. The length of road, and particulars of the gradients and curves are stated; the size of ropes and number of pulleys are also given. 400 tons per day in 25-ton trains, at a speed of five miles per hour, were hauled at a total cost—for labour, ropes fuel, oil, grease, and repairs—of 1d·893 per ton per mile.

In section C of a paper on the PRINCIPLES OF ELECTRIC LIGHTING AND TRANSMISSION OF POWER BY ELECTRICITY, Mr Sydney F. Walker deals with the subject of ELECTRICAL ACCUMULATORS OR SECONDARY BATTERIES. After giving a general description of their construction and action, he points out that under the most favourable conditions they cannot develope as much as 60 per cent. of the mechanical energy used in charging them. Among several applications of the batteries, mostly as yet in an experimental stage, he notices the very important one to the miner's lamp by Mr Stearns, who has succeeded in making a Swan lamp, giving a light of one candle; and Mr Walker thinks one might be made to give a light of 2½ candles for eight hours, without weighing more than a few pounds; but he apprehends some difficulty in effectually protecting the light without obstructing it. J. G.

A paper on the EXHAUST STEAM INJECTOR was read by Mr L. J. Groves, before the INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND, at their meeting in March, 1883. This injector is the invention of Messrs Davies, Hamer, and Metcalfe, and is designed to heat the feed water and force it into the boiler by means of the exhaust steam from the engine. At first sight, one would suppose that this could only be accomplished by throttling the exhaust; but, instead of this, its application appreciably relieves the ordinary back pressure. Two indicator diagrams are given, which were taken from an engine fitted with one of these injectors. In the first diagram, the injector is not working, and a back pressure of 2lbs. per square inch is shown; the second diagram, taken with the injector at work, shows the back pressure entirely relieved. The theory of the action of the injector, which is very interesting, is described in a clear and intelligible manner; and two plates are given showing sections of it. The only conditions necessary for its proper working are—(first) the cold water must flow into it,; (secondly) the temperature of the water must not exceed 75 degrees; (thirdly) the boiler pressure must not exceed 75 lbs. per square inch. All these are conditions which it should not be difficult to satisfy about a colliery. Although it can be attached to, and will work automatically with, an ordinary winding engine, still it is to non-condensing pumping engines we may expect its application to become most extensive about collieries. As it heats the feed water to 190 degrees, in addition to forcing it into

the boiler, the claims put forward for it on the score of economy seem to be well founded. This invention is not nearly so well known as it deserves to be, and great credit is due to its inventors for bringing it to a practical issue. -J.P.

In the TRANSACTIONS OF THE INSTITUTION OF ENGINEERS AND SHIP-BUILDERS IN SCOTLAND for March and April, 1883, there are two papers printed—both bearing on the same subject. The paper in the March number is a very exhaustive one, by Mr J. M. Gale, C.E., on THE LATEST ADDITIONS TO THE LOCH KATRINE WORKS. That in the April number is by Mr Joseph Moore of San Francisco on MALLEABLE IRON PIPING FOR CONVEYING WATER, as applied in California. In reading the two papers, the contrast in the method of working in the two countries is very vividly brought out. In the case of the Loch Katrine Works, we see how slow and laborious the progress is towards completion. These works were designed in 1854, and completed in the autumn of 1881 at a cost of £2,204,000, the total length of large cast-iron pipes, 36 inches diameter and upwards, being 44½ miles. We find the Californians adopting a different style. They take malleable iron for their pipes on account of its lightness combined with strength; and, as an example of how they go to work, the following is an instance:—The iron for 15 miles of pipes was delivered in sheets into the workshops in San Francisco in June, and it was finished, laid, and the water flowing through it before the end of the following November. Some very interesting details as to rivetting, jointing, and laying these pipes are given, and the pressures they are capable of withstanding are something enormous. Mr Moore does not wish it to be understood that he recommends wrought iron pipes at all times where cast-iron can be got for nearly the same price; but its lightness, cheapness, and the facility with which it can be laid give it a great advantage over cast-iron in many cases. Both papers are very fully illustrated, and will well repay a careful perusal.—J.P.

On SINKING TWO SHAFTS at Marsden by John Daglish Minutes of proceedings of INSTITUTE OF CIVIL ENGINEERS. Vol. LXXI., part 1.—The shafts referred to in this paper are situated on the Coast of Durham. The geological formation of the district is described, the coal underlying permeable Permian strata charged with water, a fact which led to the adoption of the *Kind-Chaudron* system of sinking, after trial had proved the ordinary method too expensive. The system of boring out shafts without removing the water, and sinking water-tight tubbing when a seat had been got in impermeable strata was proposed by Mr Kind in 1849, and worked by him for several years, but only with partial success, till Mr Chaudron invented his "moss-box," which overcame the principal difficulty, and secured a water-tight seat for the tubbing. The system might be described as mineral boring on a gigantic scale. The boring proceeds by two stages: First, a small shaft, 4 ft. to 5 ft. in diameter, is bored by a cutting tool called a *trepan*, suspended by wooden rods, worked by a steam cylinder in much the same manner as in mineral boring by steam. The trepan consists essentially of a horizontal wrought-iron bar studded with chisels on its under side, each of which cuts a small annular ring, the trepan turning round the axis of the pit through a small angle between each stroke. The debris is removed by means of a large cylinder with flap valves at the bottom called a *sludger*. The small shaft being bored 30 or 40 ft., the large trepan, of length equal to the diameter of the finished shaft, is next used. It is constructed similarly to the small one, but without chisels in the centre opposite the small shaft already cut. The debris in this case falls into the sludger placed in the small shaft. So the process goes on with large and small trepan alternately, till the water-bearing strata are passed. A ledge for the tubbing is then prepared by means of a

gigantic pair of pincers that can be opened and shut from the surface. The sinking of the tubbing is next proceeded with. The bottom and second rings form a kind of gland (the packing of moss) called the "moss-box." The third ring has an internal flange to which a metal diaphragm is attached. This diaphragm is pierced in the centre by a circular hole with flanges upon which a column of equilibrium pipes is built. By these means water is admitted to the inside of the tubbing at will and in such quantity as to keep it floating in the water as each ring is added, till it rests on the prepared seat. The space outside the tubbing is then filled with concrete, the water withdrawn, and the sinking carried on by the ordinary method. The different apparatus for catching broken rods, and dealing with other accidents, are described; and a table showing the time occupied by each stage, and cost thereof is appended.

In the after discussion, Mr Daglish supplemented his paper by a description of expansion gearing applied to winding engines; and the results. Several modifications of the Kind-Chaudron process—such as boring in one stage and with a differently constructed trepan, and seating the tubbing without the moss-box—are described. One case of sinking through running sand and mud on the shore in North Wales under compressed air is somewhat minutely explained and illustrated by diagram. J. H.

On EXPLOSIONS OF BOILERS AND OTHER VESSELS, by E. B. Marten. Transactions of the NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS. Part 4, Volume XXXII., 1883, pp. 191-200. By means of a large number of small, but exceptionally good, figures, coupled with a few explanatory words, some very interesting details are given of characteristic boiler explosions which have occurred. In addition to the more ordinary causes of explosions, these are shown in one or two instances to have resulted from a plate, even though beneath the water-line, becoming softened by overheating, caused by the flame from the furnace impinging so directly upon it as to keep up a continuous flow of steam, and prevent water remaining in contact with it, and from what is called "drum-head" motion. The former condition must not be confounded with the "spheroidal condition" of water. In the instance cited of the latter cause, the motion seems to have arisen from the varying pressure of steam during the working of a steam-hammer, causing a movement in the crown plate soon producing a line of weakness, as in paper frequently bent, aided by corrosion, from the scale being constantly driven off by the frequent bending. Professor Airy has shown that a cubic foot of water heated to the temperature of steam at 60lb. pressure has the energy when liberated of 11b. of gunpowder, and points out that the store of steam actually formed contains but little energy, but the heated water is the source of destruction. In a boiler explosion, the vacuum resulting from the condensation of steam causes a back rush of air, which often causes walls to fall towards the centre of explosion. A boiler-shell at any weak point tends to assume the best form for resistance to internal pressure, but a tube subjected to external pressure tends to get out of the circle, and is thereby weakened. It is also shown why the longitudinal seams of a cylindrical boiler are more strained than the circumferential ones. Insurance has been proposed as a remedy, but it is only useful if it is made the means of enforcing proper inspection. J. H. R.

On INTERNAL STRESS IN CYLINDRICAL AND SPHERICAL DAMS, by Professor W. Steadman Aldis, M.A. Transactions of the NORTH OF ENGLAND, INSTITUTE OF MINING AND MECHANICAL ENGINEERS, Part 4, Vol. XXXII., 1883, p.p. 201-213. From a mathematical examination of this subject, the following results are deduced:—If K be the required thickness of dam, p the given pressure of water, T_1 the greatest stress which the materials are capable of

supporting without collapsing, r the outer radius, and if the measure of T_1 be taken in the same units as p, and 10 be introduced as the factor of safety: in a cylindrical dam the minimum thickness K consistent with safety,—on the supposition that the average stress (the maximum stress being, of course, always less than T_1) alone need be considered,—will be given by the formula,

$$K = \frac{10pr}{T_1}. \qquad (1)$$

If the supposition be adopted that the tangential stress increases uniformly from the inside outwards, as is probably the case,

$$K = r\left\{1 - \sqrt{1 - \frac{20p}{T_1}}\right\}. \qquad (2)$$

On similar suppositions the minimum thickness of a spherical dam of the same materials will be

$$K = r\left\{1 - \sqrt{1 - \frac{10p}{T_1}}\right\}, \qquad (3)$$

and

$$K = r\left\{1 - \sqrt[3]{1 - \frac{15p}{T_1}}\right\}. \qquad (4)$$

A cylindrical dam will thus be found on either supposition to require a much greater thickness for safety than a spherical dam. Expense and other difficulties being left out of consideration, either form is evidently superior to a simple rectilinear barrier, whose point of most frequent inefficiency is leakage at the edge, a defect overcome by the first two forms much more satisfactorily. J. H. R.

In the Transactions for February, 1883, of the American INSTITUTE OF MINING ENGINEERS, there appear the following papers:—

THE MANAGEMENT OF STRUCTURAL STEEL, by Albert F. Hill, C.E., New York City. The results of hundreds of tests, made with the view of determining to what extent structural material is weakened by manipulation in the workshop, are clearly set forth, as also the best correctives to such weakening influences. The value of the paper is much enhanced by a series of tests and results shewn in tabulated form at the end of the paper. The author's remarks on welding are also well worthy the attention of all those who have to do with the manipulation of steel.

WATER GAS AS FUEL, by W. A. Goodyear, M.E., New Haven, Conn., may be interesting to scientists, but is yet too much in the region of experiment, and needs further development to become interesting to the general reader.

Interesting results of EXPERIMENTS ON AMERICAN WOODS, made with the view of determining their transverse strength, resistance to crushing, and also their value as fuel, are furnished in a paper read by Prof. S. P. Shales, Borponts, Mass. Though iron and steel are now supplanting wood for many purposes, wood is likely to long continue in demand; and it is important, therefore, that the very best information should be had as to the most suitable wood for every purpose. J. D.

On IMPROVEMENTS IN THE MANUFACTURE OF COKE, by John Jameson Proceedings of the INSTITUTION OF MECHANICAL ENGINEERS, London. Part 2—April, 1883. Under this title, Mr Jameson, of Newcastle-on-Tyne, describes his own method for the recovery of ammonia and tar during the process of coking, in the course of his paper making slight, but also rather slighting, reference to some other methods. But the present and growing importance of the subject justifies a full examination of all the plans proposed. The earliest suggestions on the subject are those of the patents of the Earl of Dundonald, 1781; of W. E. Newton, 1852; and of E. Jones, 1859: but the process introduced by Pernolet in 1864 (proceedings of the INSTITUTION OF CIVIL ENGINEERS—May 10, 1864,) seems to have been the first attempt on a large scale to carry out the manufacture of coke, along with the recovery of the various products of distillation. (See PERCY'S METALLURGY, Vol. on FUEL, 1875 edition, pages 490-497.) This process yielded 60 to 64 per cent. of coke, with about 6 gallons tar per ton of coal, and 0·26 per cent. sulphate of ammonia; but, in practice, it failed on account of the large cost of repairs on the brickwork of the ovens, and on account of the quality of the coke being unsuited for use in blast furnaces. Mr Jameson's method is applicable to bee-hive ovens and consists in providing a series of channels in the bottom of the oven, covered by perforated quarls and leading to a central passage or orifice, with which is connected some apparatus for sucking the gases and liquid matters given off during coking, and for subsequently dealing with them. Mr Jameson's general remarks on the products obtained from coal, and his theory of the action of coking in general, and in his own ovens, are interesting and valuable, but do not affect the practical value of the process. That rests upon such considerations as—(1) Whether air can be excluded from the bottom of the ovens in presence of the means used to create a partial vacuum there; (2) Whether wear and tear will be greater on account of a higher heat of coking; (3) Whether the quality and quantity of the coke are improved or deteriorated; (4) Whether the full value of the secondary products can be realized. As to these, the paper furnishes us with no actual results concerning 1 and 2; but it appears that (3) the yield of coke is not increased from that of the ordinary bee-hive ovens, amounting to about 58 per cent. of the weight of the coal, the quality also remaining the same; and that (4) part of the economy of the process depends upon the sale of the large quantity of gas produced. The quantities of tar and sulphate of ammonia recovered, as given by Mr Jameson and several of those who discussed the paper, vary so much as to leave that part of the subject in some uncertainty. With regard to the gas produced in coking, Mr Charles Cochrane (who is no mean authority in metallurgical matters) pointed out that the proper way to secure economy by its use is to utilize it as much as possible on the spot, and for the operations in which it is produced. Generally a portion of it is made use of to raise steam at the Colliery; and in the ordinary bee-hive oven the combustion of some of the gas in the ovens themselves aids the process of coking. In Mr Jameson's ovens this latter cannot take place unless by leakage of air where it is not wanted and would destroy the products; and, as a consequence, the air which is admitted at the top of the ovens must cause the combustion of some of the coke itself. This is decidedly against this process. The plan proposed by Mr Henry Aitken, in Proceedings of the NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, Vols, XXIV., 1874, and XXIX.; 1879, is preferable from this point of view, as is also the one mentioned by Mr Cochrane in the discussion on Mr Jameson's paper. But the results obtained by the Simon-Carvès system (Journal of the IRON AND STEEL INSTITUTE, No. 1, 1880,) place this method ahead of any that have been introduced, not excepting the Otto oven referred to by Mr H. Bauerman as one of the most perfect of the class which makes use of the gas for heating the oven itself. The recovery of ammonia and tar produced from coal by COMBUSTION (as distinguished from DISTILLATION), of which we have examples in blast furnaces and gas producers, is a separate branch of the subject, and one which is necessarily not touched upon in Mr Jameson's paper. F. J. R.

THE MINING INSTITUTE OF SCOTLAND.

SUMMER MEETING, 16th AUGUST, 1883,

HELD AT HAMILTON.

The Members met at the Hall of the Institute at 12 o'clock noon, whence they were conveyed to CADZOW COLLIERY. They were there received by Mr Austine, the managing director of the Cadzow Coal Coy. (Limited), and Mr Hamilton Smith, the manager, by whom the fittings and arrangements above and underground were shewn and described.

This colliery, which is one of the largest in the Hamilton district, has three pits fitted and in full operation. Above-ground the large Cornish pumping engine erected on No. 1 Pit; the two ventilating fans—one 40 feet diameter, and the other 28 feet diameter, worked a fortnight each alternately —and the arrangement of screens whereby the large output is sorted for the market, engaged the largest share of attention; and under-ground the haulage engines, which are erected at the bottom of No. 2 Pit, and the arrangement of pulleys and ropes in connection with the very extensive and complete system of underground haulage at this colliery were examined with interest.

After lunch, which was kindly provided by the Company, Colonel Hamilton, M.P., was introduced by Mr James Smart, vice-president, and addressed the members on the subject of the Fleuss Life-Saving Apparatus.

Colonel HAMILTON, M.P., said he belonged to their Association, and had hitherto contented himself with reading their proceedings, which he had done with great interest. He never would have dreamt of attending the present meeting for the purpose of suggesting anything to practical men such as they were, but his

excuse was this: In London he got three or four letters from a Mr Fenwick asking him to attend meetings in London for the purpose of forming an Association for establishing the Fleuss apparatus for saving life in mining districts. He did not attend, because in speaking to several gentlemen in the House of Commons on the subject he came to the conclusion that the meeting would not lead to any practical result. But the other day, being in communication with their Secretary, he mentioned that he would like to bring the subject before the members of the Institute; and he merely wished to do so now. This Fleuss apparatus,—he did not know but that they would be aware,—was a dress by which a man could go under water, or into foul air, and walk about without being suffocated; and it had been found of great use in cases of accidents by explosions in mines. He wrote to Mr Fenwick in view of this meeting, but had got no answer, and he could give no special information. However, the Secretary had some notes on the subject, which, with their permission, he would read to them.

THE FLEUSS BREATHING APPARATUS AND LAMP FOR PENETRATING NOXIOUS AND INFLAMMABLE GASES.

In a lecture delivered on 6th May, 1880, by Dr B. W. Richardson, of London, and published in the journal of the Society of Arts of 14th May, 1880, the apparatus was described; and Mr Fleuss, under the direction of the lecturer, gave a demonstration of its use by going, invested with the apparatus, into a chamber, of a capacity of about 45 cubic feet, charged with an unbreathable mixture of carbonic acid and air, and remaining in it a considerable time.

The lecturer stated that he had, on 25th November, 1879, caused Mr Fleuss to be put into a diving bell which had been filled with carbonic acid—a light being extinguished the instant it was put into the bell—and that he sat in it for 20 minutes without his pulse or temperature being affected. He afterwards

charged the bell, still containing carbonic acid, with amyl hydride —a very light gas. In this mixture any one would probably die in 60 seconds. Mr Fleuss was put into it and remained 20 minutes, his temperature and pulse being exactly the same at the end of that time as at the beginning.

He had also made experiments with the apparatus under water, putting Mr Fleuss into a tank filled with water to a depth of 12 feet and at a temperature of 3° above freezing point. He remained under water precisely an hour, walking, picking up articles thrown to him, and reclining on the floor of the tank. There was at the close of the experiment a considerable acceleration in the pulse—(which was attributed chiefly to the exertion of ascending the ladder, loaded with a weight of 116 lbs.,) and a lowering of the temperature 6°. The dress was immediately removed and warm clothing put on; and the functions were again perfectly natural in 27 minutes.

Dr Richardson appeared to think that there would be some danger in working for any length of time if the temperature were reduced from 98° (the normal temperature of the human body) to 92° as in this experiment; but he did not consider that the state of the pulse indicated danger.

The conclusion he had come to in these experiments and others with regard to the apparatus was that there would be some degree of danger in using it in extreme heat or extreme cold.

He also stated that Mr Fleuss had been under water to a depth of 25 feet, and had walked under water a distance of 400 yards and had felt no embarrassment.

In a paper read by Mr Joseph Dickinson, the Inspector of Mines, before the Manchester Geological Society, on 3rd April, 1883, the apparatus is described as follows (see Trans., Part VII., Vol. XVII., pp. 101-104):—

"The apparatus is patented by Messrs Foster & Fleuss, and consists of an arrangement by which the air is filtered, and after being purified with pure oxygen is taken into the lungs. A flexible mask covers the face, and tubes are provided for inhaling and exhaling the air. The lamps are self-contained and portable. They give a brilliant light for four hours, either in water or in the most inflammable gas, without any chance of extinction or of explosion. The apparatus had been successfully used at Burton-

on-Trent, as well as in the Seaham Colliery. In the latter colliery the apparatus and lamp enabled the men employed to penetrate a considerable distance in advance—in one instance upwards of 300 yards—to examine the state of the roads which were filled with gas. The men were frequently enabled to continue at work, in putting up the brattice, when it would have been totally impossible to do so if the ordinary safety lamp had been used. Usually the gas was taken from London, compressed in wrought iron bottles, but at Seaham there was so large a quantity required that it was made on the premises. The apparatus, in addition to being of use in mines, would be available in cases of fire on board ship, and for examining ship bunkers."

"A fuller description, given by the inventors, may also be added :--"

" 'The principle of the apparatus is that the wearer breathes his own breath over and over again—the carbonic acid being absorbed from it at each expiration, and the requisite amount of oxygen being restored, the revivified breath is fit to be again inhaled in the form of pure air.

" 'The apparatus, which is carried upon the back of the diver or explorer, consists of a strong sheet copper cylinder, 12 inches by 6½ inches, with domed ends, and capable of holding four cubic feet of oxygen gas at a pressure of 16 atmospheres. Above the cylinder, and attached to the side of it, is a square metal box, 12 by 12 by 4 inches, to contain the carbonic acid filter, which is a box of vulcanite, divided into four compartments, and with a wooden lid made air-tight by an india-rubber washer, and having an inlet and an outlet tube ; this box is filled with a packing of ordinary tow, interspersed with two pounds of stick caustic soda. The exhaled breath passes twice up and down through the interstices of the tow, by which it is finely divided and thoroughly freed of carbonic acid by the caustic soda, the excess of moisture collecting under a perforated false bottom arranged for the purpose.

" 'A flat bag of vulcanized india-rubber is fastened to the apparatus, and is connected by an india-rubber pipe over the shoulder to the outlet pipe of the filter ; the bag is also in communication with the oxygen chamber, and the supply of oxygen to the bag can be regulated by a jamb screw valve under the control of the wearer.

" 'An india-rubber mask is make to fit air-tight to the face, and is held in place by straps buckled up at the back of the head. The mask is fitted with a pair of flexible valved pipes, the one for exhaling being in communication with the inlet pipe of the filter, and the other for inhaling in communication with the air bag.

"'The exhaled breath having passed through the filter enters the bag in a purified state, and there meeting with its complement of oxygen is fit to be again inhaled. The bag being perfectly flexible readily expands or contracts as the breath passes in or out of it, so that no effort is required in respiration.

"In practice, it seems that this mask has been found painful, owing to the pressure of the bands upon the head, and that Denayrouze's is preferred."

"'Foster & Fleuss's Patent Safety Mining Lamp is a modification of the lime light, methylated spirits of wine being used instead of hydrogen gas; and consists of a strong copper sphere, 7 inches diameter, and capable of being charged with oxygen at a pressure of from 16 to 20 atmospheres. To the top of the sphere is attached a small spirit lamp, with two wicks, between which, through a small jet, a minute stream of oxygen, regulated by an adjusting valve on the sphere, is allowed to pass, carrying the flame against a cylinder of lime held on a stud placed to receive it.

"'The light is covered in by a double dome-shaped metal casing, having an annular space left between its inner and outer surfaces, which is filled with water; discs of plain glass are inserted opposite each other in the inner and outer casings, and a small outlet valve is fixed in the inner case, near its lower part, for the escape of the products of combustion from the inside of the casing into the annular space filled with water between the two cases, through which the gases bubble and escape through another outlet valve fixed on the top of the outer case. The cover is attached to the lower part by means of a screw, an air-tight joint being made by a leather washer seating.'"

"The inventors state that the apparatus 'will supply breathable air for four hours at a time;' and that the lamp 'will burn for four hours equally well under water, in carbonic acid, or in fire-damp, and that it cannot get hotter than boiling water.'"

At the meeting of the Manchester Geological Society, held on 5th June, 1883, the following further information was elicited:—

Mr Brown, a representative of the patentees, said that he wore the apparatus 37 minutes at a trial before the Fire Department of New York in a chamber filled with dense smoke. The mask —at first uncomfortably tight—got easier as his face warmed and he began to perspire. He felt better at the end of the 37 minutes than during the first 15, and was ready to go on for an hour, but the people got tired waiting outside. In answer to a question, he stated that the apparatus had not been used by any

one for four hours consecutively; but at Seaham it was used by one person for two hours. For two hours' work it was exhilarating in its effects.

The Breathing Apparatus, with a bottle of oxygen to last 16 hours, costs £25, the Lamp £13 10s, and an Oxygen Bottle, fully charged, £4, being equivalent to between 4 and 5 charges of the breathing apparatus; but the bottle could be refilled for 15s.

In answer to a question by Dr. Le Neve Foster, Mr Brown stated that the oxygen would keep in the bottles for any length of time. Dr. Foster thought there might be some danger of the absorption by the caustic soda being prevented, through the carbonic acid of the expired air converting the caustic soda into a carbonate and forming an outer coating of carbonate of soda. Mr Brown, in reply, stated that that had been tested, and it was found that when the apparatus was in constant use the carbonate of soda broke away with the heat; but when the apparatus was put aside for some time it was necessary to rub off the coating.

In his report to the Home Secretary for the year 1880, Mr Bell, Mines Inspector for the Durham District, stated :—

"During the very tedious and dangerous operations of reopening the Maudlin Seam at Seaham Colliery (after the explosion there of 8th September, 1880), the Fleuss Breathing Apparatus and Lamp were found to be of the greatest possible value in enabling the explorers to go forward and ascertain the state of the mine, and to continue their work when the gas became troublesome by backing out faster than it could be diluted and carried out into the returns. I consider them to be very valuable in cases of fire or outbursts of gas, or even irruptions of water; and would be glad to see them kept ready for use at every colliery. They are light, portable, and easily managed."

From a letter written by Mr T. A. Walker, the Contractor of the Severn Tunnel, to the Editor of the *Times*, on 19th Nov., 1880, it appears that a diver invested with the Fleuss apparatus walked 340 yards into the tunnel, which had become flooded, pulled up rails, shut two sluices, and closed an iron door, he having been wholly cut off from signals for an hour and a half.

In connection with the explorations after the explosion at Killingworth Colliery in April, 1882, Mr Willis, Inspector of Mines for the Northumberland district, in his report for the year 1882, states as follows :—

"Telegrams had been sent to Seaham Colliery asking the loan of their Fleuss Breathing Apparatus, and to send men capable of using it; and no time was lost in sending this off. The bratticing still went on and men were sent to the bottom, which they could now reach, but could not proceed any further, lights still being extinguished by the carbonic acid. . . . By 10 p.m. (the accident occurred soon after 6 a.m.), the Fleuss apparatus had arrived and had been got into working order. Three men dressed with the apparatus, two from Seaham who had been accustomed to wear it and one of the Killingworth men who was well acquainted with the shaft bottom, descended, taking with them the apparatus, lamps, and also ordinary safety lamps; but, at once on reaching the bottom, the breathing apparatus with which the Killingworth man was dressed became disarranged, possibly because of his nervousness, and all were at once again drawn to the surface. It had been noted, however, that the ordinary lamps now burnt freely at the bottom; and therefore, while the Fleuss Apparatus was being arranged, the shaft men descended and, without much difficulty, communicated with the ten men, whom they found in a very exhausted condition. The three men with the Breathing Apparatus (an experienced man having been put in the place of the man upon whom the apparatus became displaced) again descended, and the apparatus was found of great use in giving each of the exhausted men a "whiff" of oxygen, which revived them much.

"I have described this somewhat at length, as much was said at the time in public newspapers and elsewhere as to the saving of the men being entirely due to the Fleuss Breathing Apparatus. It will be seen that this was not the fact, although as to its usefulness on such like cases there cannot be any doubt. Had a set of breathing apparatus been upon the place there is no doubt but it would have enabled the rescuers to pass safely through the 100 or 120 yards from the shaft bottom to where the imprisoned men were congregated; but it will be seen that unless the rescuers could have carried with them spare breathers for those imprisoned they could not have brought them to the shaft bottom through the long distance of carbonic acid gas; nor could they have done anything more than was being done from the surface towards restoring the ventilation sufficiently to get the men out."

Colonel HAMILTON, in concluding, said his duty was discharged in mentioning the subject, leaving it to them to take such steps as they deemed necessary. He might say, in this district they were luckily very free from accidents such as the Fleuss apparatus might be usefully em-

ployed in. Their accidents were mostly from falls of roof. However, they were the gentlemen best qualified to form an opinion on the subject. He thought he had read enough to shew that it was no humbug. As he had said, he felt it his duty to bring the subject before them, and should they consider that it would really do good, he would be gratified, and would assist in its establishment in every way he possibly could. (Cheers).

Mr JAMES SMART, who, as vice-president, occupied the chair in the absence of Mr James M'Creath, said they needed no apology from Colonel Hamilton for bringing this important matter before them. They were rather indebted to him for doing so. (Cheers.) He might explain that it had already occupied the attention of the Council, and they might by and by ask the Institute to say whether it would be necessary to form associations to establish the Fleuss apparatus in different districts. According to the information at present in their possession, the opinion of the Council was that it had certainly done wonders in some cases, and it had not been so successful in others. He hoped in a short time that they would be able to test its merits, and the question of forming associations would then be laid before the Institute. Mr Smart concluded by asking the members to accord to Colonel Hamilton a hearty vote of thanks for the trouble he had taken in meeting them there that day. It was but another proof of the lively interest which Colonel Hamilton took in everything that affected the industry in which they were all deeply concerned. (Cheers.)

Colonel HAMILTON, in reply, said his object was gained in having the subject taken up. He was much obliged to them for the vote of thanks.

The SECRETARY proposed a hearty vote of thanks to Mr Austine for the cordial way in which he had met the members of the Institute, as well as the hospitality he had shewn them.

The call met with an enthusiastic response.

Mr AUSTINE, in returning thanks, said he was glad to see them all there, and he hoped their visits would be repeated as often as they thought proper.

The members were then conveyed to EARNOCK COLLIERY,

the property of John Watson, Esq., of Earnock. They were received by Mr James Gilchrist, the manager, who conducted them over the works. The electric light, which was installed at this colliery two years ago, and is still in use at the pit bottom and in the principal roadways, excited special interest. There are two pits in operation at this colliery, one being used entirely as an upcast and for the conveyance of men and materials underground, the other being used exclusively for raising the coal, the output of which is very large. The pithead frames and other erections, which are entirely of iron, and the arrangements at No. 1 Pit for the disposal of the whole output had a large share of attention, as also a room at the pithead which has been tastefully built and fitted up with appliances approved by the St. Andrew's Ambulance Corps, and where persons who have met with any accident at the colliery can be attended to before being removed to their homes.

Refreshments were kindly provided by Mr Watson; and before the members left a hearty vote of thanks was awarded to him and to Mr Gilchrist.

Arrangements had been made for visiting Cadzow Forest, and Hamilton Low Parks and Mausoleum; and advantage was taken of the opportunity. A party visited Cadzow Forest in the early part of the day, and the greater number of the members went to the Low Parks and Mausoleum on the return from Earnock Colliery.

By arrangement the members dined at the Commercial Hotel at 5 o'clock—J. S. Dixon, Esq., vice-president, in the chair.

Immediately after dinner there was held a

GENERAL MEETING.

JAMES S. DIXON, Vice-President, in the Chair.

Seventy members were present.

The minutes of the previous General Meeting were read by the Secretary and confirmed.

The following gentlemen were elected by ballot, and admitted as Ordinary Members.

W. T. CURRY, Usworth Colliery, Co. Durham.
ANDW. LAIRD, 1 Corunna Street, Glasgow.
JOHN NAPIER, Haywood Colliery, Lanark.
ALEX. EASTON, Haywood Colliery, Lanark.
W. M'WHIRTER, 219 Argyle Street, Glasgow.

DISCUSSION OF MR ROBT. THOS. MOORE'S PAPER ON "FRENCH VIEWS OF ENGLISH MINING."

The CHAIRMAN, in inviting discussion on this paper, remarked that it was a very useful thing to know what foreigners were saying about them. In fact, they might quote Burns on the subject—

"O! wad some pow'r the giftie gi'e us,
To see oursels as others see us!"

Mr RALPH MOORE said he had always found that these annual meetings were not conducive to the reading of papers. (Hear, hear.) They were more inclined to be festive, so that he was afraid they would not have very many remarks on this paper. He thought it was very important, as their Chairman said, that they should see what others said of them. The paper contained what was most interesting without going into descriptions which they had had already from the Propping Committee the Institute had sent out. He met one of the French Commissioners; and a more industrious gentleman he had never come in contact with. He well illustrated a favourite notion of his (Mr Moore's) own that every manager and every one connected with mining should be able to sketch freely with the hand, and should endeavour to do so to a scale corresponding to the subject he was at. He showed this French Commissioner the large plan of a colliery on a half-inch scale, which he sketched on a much smaller scale. The Commissioner made all his memoranda and sketches on small cards, about the size of playing cards, instead of a book; and as one card was filled he put it into an envelope, and took another. His memoranda were in French; and he was not able to

see what they were, but judging from the translation he seemed to have made a very good use of his time. That, he thought, was well worth noting. It was an invaluable acquisition to be able to sketch freely. They should all try it. He did not know that there was much room for discussion in the review. The report was the best he had seen of any of the French Commissioners that had come under his notice. They seemed to know more about the history of the inspection of mines than many of ourselves.

Mr J. H. RONALDSON said there was one slight inaccuracy on the part of the Commissioners in speaking of building, because in some parts of Wales they built up the goaves, and this would appear from what the Commissioners themselves stated.

The CHAIRMAN—They may only have been talking of the general practice. This is an exception to the general rule.

Mr R. T. MOORE—What the Commissioners called attention to was the taking of rubbish from the surface to build up the waste when the brushing did not supply sufficient to do so.

The SECRETARY said they could not but admire the industry of the Commissioners in gathering so much information together in such a short time. At the same time, the very amount of material would lead them to suppose they might have made slight inaccuracies now and again. There was one remark that had been made with reference to the system of paying lordship, which, he thought, was apt to mislead. It was said the lordship was paid according to the proportion of the sale price, which in Staffordshire was often a third. He feared, if that was correct for Staffordshire, it was not correct over the whole country. Certainly one-third of the sale price was very different from the proportion stipulated for in leases in Scotland. One noticeable thing in connection with ventilation both in France and Germany was the use of malleable-iron pipes, instead of bratticing, composed of cloth or wood. They seemed to have been interested at the universal use of bratticing in this country. He was not aware of ventilation by pipes having been carried out systematically except in one colliery not far distant, and he did not know whether it was there considered an improvement or not. It would be interesting to know if it was a sufficient mode as well

Commissioners made regarding their reports. At P. 79 they said :—"The daily reports are signed in a very formal manner." With regard to this, he thought those looking at those reports—say under the 30th General Rule—would find that often from the beginning of the year to the end they showed a clean sheet. Apparently the man who made the examination found nothing wrong, while they all knew that defective parts of the roof in roadways, &c., were frequently found in most pits. The workmen make their examination daily, and reported in this manner; and he thought they ought to put it into their report if a defective road or the like was found. The report book was for this purpose, but this was not always attended to,—at least in his experience.

Mr D. ANDERSON said Mr Barrowman had made reference to the air being carried in by iron tubes or pipes, and the Commissioners seemed to reflect seriously on the mode in use in this country of carrying in the air to the working faces. There was some reference made, he thought, in a paper translated by Mr Ronaldson, giving instances of the mode of carrying air in by tubing in Germany, and they came to the conclusion, at least some of them who were at the Institute meeting, that they had really but small quantities of air to dispose of, and it was an absolute necessity to conserve it in some way in order to get the men to work at the face. He thought, if they had a defective mode with the large volumes of air that they had, they had still a very good system of distribution. and it kept the working faces clear and well ventilated. Mr Robson had been round the collieries recently, testing the amount passing through, and he was able to speak with some authority on the subject. It was, therefore, satisfactory to hear from him that 30 per cent. of the air passing down the shaft reached the faces, for that still left a pretty good ventilation passing round the working faces. It was possible if they were resorting to the system of carrying the air in with tubes it might be better conveyed to the faces. He had seen it carried with tubes a distance of 200 fathoms, and very little air lost from what went in at the downcast till it was delivered at the face; but it could only be resorted to economically and successfully where they were driving mines. Possibly, it might

be a difficult matter to do so round a stoop-and-room working. It would take a great deal of time to fit it in, and would be a little more expensive than bratticing in working with, and seeing they had a large volume of air he thought the bratticing served their purpose very well indeed. If any one had any experience of tubing round the working face, it would be well for them to hear it. His experience had been in driving mines, one 100, and another 250 fathoms, and the tubing, which was of sheet iron, 2ft. 10in., and 2 feet in diameter, gave good ventilation.

Mr R. T. MOORE did not think the Commissioners expressed any decided opinion against bratticing. Not that they approved of it rather than sheet iron pipes—they did not express any decided opinion on the subject.

Mr J. M. RONALDSON said, with regard to piping, he had seen fireclay pipes, two feet in diameter, with the joints clayed up, for purposes of ventilation; but this could only be used to a limited extent.

Mr DRINNAN said the Commissioners seemed to have been struck somewhat by the clean sheet which those daily reports presented at the end of the year. He thought they had a right to hear from Mr Ronaldson some justification of this, but he had done the opposite—he had endorsed the opinion of the Commissioners. He thought it would have been possible for him to have explained it. In many collieries men were employed during the night remedying any defects in the roadways for next day. He knew that was done in a good many collieries; he would not be surprised to hear that it was general throughout Scotland, and that would enable the fireman to declare them in a good state. He thought Mr Ronaldson ought to have found such an explanation, if only for the honour of his country.

The CHAIRMAN said his idea was that they could not well compare French, English, and Belgian mines. They must take every district by itself. People, in nothing more than in mining, must adopt the best principle applicable to the state of matters with which they were dealing. Their mines were so different from those of the French, and, further, they produced such large quantities of coal and required such large quantities of air, that

the mines of the two countries were not comparable. The French worked their mines in small sections, so far as he understood, and on steep angles, driving cross-cut mines, and ventilating in small districts. In this country, on the other hand, their workings extended over hundreds of acres. The consequence was they had to take in air and draw their coal long distances. During the course of English mining, especially during the last thirty years, they had probably gradually assumed the best systems under which they could conduct such mines; and this progress must continue. The Chairman, in closing the discussion, moved a vote of thanks to Mr R. T. Moore for his paper, which was cordially given.

EXPERIMENTS WITH FORCING AND EXHAUSTING FANS.

By Mr ROBERT BEITH.

On looking over the papers that have already been read by members of this Institute, I find that the subject of Ventilation has been ably taken up on two occasions, the papers fully discussed, and the merits of the exhausting fan gone into; but no statistics whatever have been given as to the results of the forcing fan.

Many opinions exist as to the merits of the different mechanical appliances for producing currents of air. Some mining engineers hold that exhausting fans can be run with less expenditure of power to produce a given result than forcing fans. We shall, therefore, ask your consideration whilst we institute a brief comparison of the two systems.

There is a forcing fan employed at the downcast shaft at Townlands Colliery. This shaft, which is rectangular in form, is 24 feet long by 7 feet wide inside of wood, and is 117 fathoms deep. The up-cast shaft is circular, 11 feet diameter inside of brickwork, and is 113 fathoms deep. It is situated at a distance of 726 yards from the down-cast shaft. The workings ventilated by means of this fan extend 1320 yards in one direction, and

1140 yards in the other, with an average area of 60 feet in air-courses. The fan is driven by a horizontal steam engine, the cylinder of which is 14in. diameter, and the length of stroke 24in., the indicated steam pressure at the boilers being, on an average, 45lbs. to the square inch. The fan is 20ft. in diameter, by 5ft. broad, and is what is termed a double-eyed fan, that is, it has two air inlets on the centre of the fan, with an area in each orifice of 48 square feet. It is connected by a tunnel or drift with the down-cast shaft, the drift being 44 square feet in sectional area, and 75 feet long.

In applying this fan at the top of the down-cast shaft, an arrangement had to be made for covering the top of the shaft by means of air-tight covers, fixed in the same way as they are at up-cast shafts or where exhausting fans are applied to winding shafts.

The forcing fan employed at the downcast shaft produces currents of air by means of its centrifugal force, that is to say, it presses or forces weight on the air by which its density is increased at the down-cast to overcome the pressure of the atmosphere at the up-cast.

The work done by the forcing fan is expressed by the friction which it overcomes in the air passing through the air-courses and out at the up-cast shaft, multiplied by the square of the velocity of the air in thousands of feet per minute, multiplied by the co-efficient of friction, or, in the formula of Atkinson— $p\,a = k\,s\,v^2$.

As the results of experiment I have obtained the following facts:—At a speed of 20 revolutions the anemometer recorded a velocity of 562 feet, with a water gauge of ·15 inch. At 40 revolutions the velocity increased to 1030 feet and the water gauge to ·45 inch. At 60 revolutions (the usual speed) the velocity further increased to 1615 feet, with a water gauge of ·70 inch. Multiply the last result into the area of the fan tunnel, and a total quantity of 71,060 cubic feet of air per minute is obtained.

The exhausting fan at Backmuir Colliery is driven by a steam horizontal engine, the cylinder of which is 16 inch dia., and the length of stroke 16 inch; the indicated steam pressure at the boilers

averages 50 lbs. to the square inch. This fan is of the same dimensions as the forcing fan, viz., 20 feet dia. by 5 feet broad, and is a double-entry fan. It is connected with a fan tunnel to the ~~down~~ cast shaft, the tunnel being 56 feet sectional area and 53 feet long. There are two shafts here. No. 2 pit is rectangular, 24 feet long by 7 feet wide inside of wood, and is 122 fathoms deep. It is used for pumping water and drawing coal, and is the down-cast for the Ell coal seam. No. 3 pit is 47 yards from No. 2. It is of the same size, and is 110 fathoms deep to the Ell coal, and 122 fathoms to the Main. The space for drawing coal is 112 feet in area, and is the downcast for the Main coal seam; the other space, which is 56 feet area, is the up-cast for this colliery. The workings ventilated by this fan extend in the Ell coal to 836 yards in one direction, and 225 yards in the other, the average sectional area of air-courses being 50 square feet. The workings in the Main coal seam extend to 550 yards in one direction, and 660 yards in the other, and the average sectional area of air-courses is 40 square feet.

The work done by the exhausting fan is expressed by the vacuum which it creates, and which nature seeks to restore by her own law of the equilibruim of forces; it is exactly the reverse of the process employed to obtain the same result in the forcing fan, and can be expressed also in the formula $p\,a = k\,s\,v^2$.

As the result of experiment, I have obtained the following facts:—At a speed of 20 revolutions, the anemometer recorded a velocity of 463 feet with a water gauge of ·10 inch.

At 40 revolutions, the velocity increased to 939 feet with a water gauge of ·45 inch.

At 60 revolutions (the usual speed), the velocity further increased to 1216 feet with a water gauge of ·60 inch. Multiplying the last result into the area of the tunnel, a total of 66,880 cubic feet of air passing per minute is obtained.

I am perfectly satisfied, from the experience that I have had, that I can obtain a better result from the forcing fan than what is obtained from the exhausting fan; the upkeep of the forcing fan is not a tithe of what it takes to keep up the exhausting fan.

During the time these experiments were made with the fans, diagrams of the fan engine were taken at the different speeds,

namely, at 20, 40, and 60 revolutions. It was also deemed advisable to shut the air completely off both fans, and run the engines at the speeds previously run, and take diagrams again so as to get the amount of power spent in turning the fan and engine.

It will be seen by the diagrams (plates 2 and 3) that the proportion of useful work at the different speeds is :—

	At 20 Rev. Per Cent.	At 40 Rev. Per Cent.	At 60 Rev. Per Cent.
Forcing Fan.....	43·3	35·0	44·5
Exhausting Fan.....	30·8	45·7	28·4

The barometer at the time the experiments were made, stood at 29·16 inches, and the thermometer at 60 Fahrenheit.

I have now placed all the facts and figures relative to the work of the two fans before you, and have to give, as my opinion, that forcing ventilators are better and more economical than exhausting ones. I might have given more exhaustive analyses of the results I have obtained, but found that my time would not allow of this being done.

Mr R. Moore asked if Mr Beith in his forcing fan opened the doors at the surface so as to allow the fan to do the utmost work.

Mr Beith replied in the negative. The doors were not open.

Mr Moore said it would have been very instructive to have seen what air the engine would actually discharge with the doors all open.

Mr Beith said he could do this by next meeting.

Mr Moore said he was just thinking, as Mr Beith read his admirable paper, how many managers in the "good old times," referred to by Mr Smart, knew the equation for the retardation of air or the laws which governed the flow of air. He suspected there were not very many. That marked the progress that was being made more really than anything he had seen for a long time, and he thought the Institute might take some credit for this. Regarding ventilation, the formula for it was "large air-ways and plenty of them." The true test of a fan was to let it exhaust or expel out into the open air. Then they got the greatest quantity which the fan would discharge. With regard

to the exhausting and propelling or forcing fan, he did not think theoretically it made any difference. They were six and half-a-dozen.

The CHAIRMAN thought Mr Beith should follow up Mr Moore's suggestions and make further experiments. He could close up the drifts so as to give each fan the same area and the same speed: and in each case note what quantity of air was passing. That would be quite a reliable test. He agreed with Mr Moore that theoretically it was quite the same whether they exhausted or propelled, but he had always the opinion that propulsion in practice was a mistake, and he should be very glad to hear anything to the contrary.

Mr DRINNAN, in view of the importance of the subject, thought it would be well if Mr Beith were to have careful measurements made of the length and breadth of the several air-ways, because he believed both with Mr Moore and the Chairman that the air-ways had something to do with it, and that alone. He remembered at a colliery in England, when speaking of what would happen if the doors leading to the fan were left open, that the party he was speaking to said the engine would run away. He (the speaker) said there was no fear; it would go slower. The person was so incredulous that he had it put to the test, and the speed of the engine fell 10 strokes.

The CHAIRMAN said what they wanted was the air-ways and the fan drift.

Mr DAVID RANKINE suggested that the proposed experiments should be brought down to the practical form of showing the £ s d saving of the one over the other.

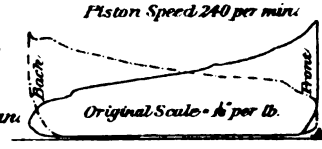
It was remitted to the Council to associate with Mr Beith a committee in making the experiments.

A vote of thanks to Mr Dixon for his conduct in the chair terminated the proceedings.

EXPERIMENTS WITH FORCING FAN.

CLYDE COAL COY.,
TOWNSLANDS PIT,
HAMILTON.

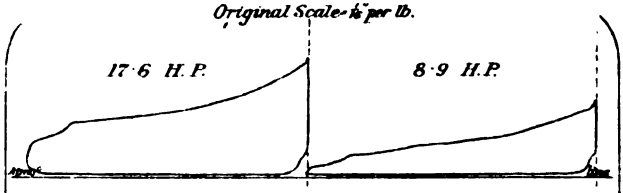
Nº 1 Engine. Nº 1 Fan.
11th August, 1883.



Diaº of Cylº 14"
Stroke - 2 feet.

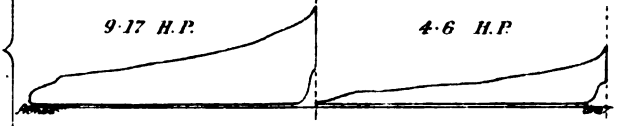
Diagrams taken with Fan inlets open.

3d Experiment, Piston Speed - 240 feet per minute.
Original Scale - ½ per lb.



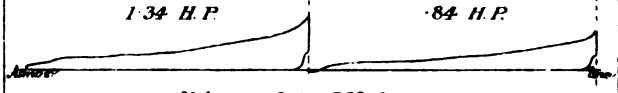
Velocity of air - 1615 feet.
Quantity " " - 71060 Cubic feet.

2nd Experiment, Piston Speed - 168 feet per minute.
Original Scale - ½ per lb.



Velocity of air - 1030 feet.
Quantity " " - 45320 Cubic feet.

1st Experiment, Piston Speed - 80 feet per minute.
Original Scale - ½ per lb.



Velocity of air - 562 feet.
Quantity " " - 24728 Cubic feet.

Diagrams taken with Fan inlets closed.

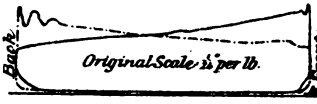
NOTE. All the Diagrams are one third of original size.

EXPERIMENTS WITH EXHAUSTING FAN.

CLYDE COAL COY.,
BACKMUIR PIT,
HAMILTON.

Nº 2 Engine, Nº 2 Fan
11th August, 1883.

Piston Speed 160 ft per min.

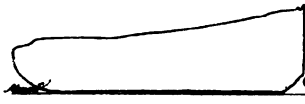


Diameter of Cyl.r 16"
Stroke - 16"

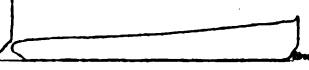
Diagrams taken with Fan inlets open.

3d Experiment, Piston Speed 160 feet per minute.
Original Scale - 1/20 per lb.

22·28 H.P.



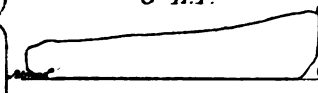
10·28 H.P.



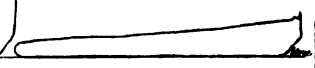
Velocity of air - 1216 feet.
Quantity " " - 66880 Cubic feet.

2nd Experiment, Piston Speed - 112 feet per minute.
Original Scale - 1/10 per lb.

8 H.P.



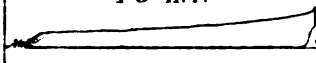
4 H.P.



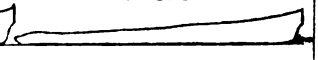
Velocity of air - 939 feet.
Quantity " " - 51545 Cubic feet.

1st Experiment, Piston Speed - 53⅓ ft per min.
Original Scale - 1/3 per lb.

1·3 H.P.



1· H.P.



Velocity of air - 463 feet.
Quantity " " - 25465 Cubic feet.

Diagrams taken with Fan inlets closed.

NOTE. All the diagrams are one third of original size.

The following are the additions to the Library since 12th April, 1883:—

DONATIONS.

Tangye Brothers Large Illustrated Catalogue of Machinery, Tools, &c.—*From the Proprietors.*

Spontaneous Combustion of Coal in Cargoes. Some facts connected with Spontaneous Combustion of Coal in Cargoes. The Doterel Explosion. Disease and Putrescent Air. Explosions of Gas in Coal Bunkers, by Thomas Rowan.—*From the Author.*

The Colliers' Strike in South Wales, by George Dalziel.—*From John B. Dalzell, Lesmahagow.*

Vol. IV. of the Transactions of the North of England Institute of Mining Engineers.—*From James Barrowman, Hamilton.*

Manchester Steam Users' Association: Monthly Report, January —June, 1883.—*From the Association.*

RECEIVED IN EXCHANGE FOR THE TRANSACTIONS OF THE INSTITUTE.

Manchester Geological Society: Transactions, Parts 5—9, Vol. XVII.

North of England Institute of Mining and Mechanical Engineers: Transactions, Parts 3, 4, Vol., XXXII.

Institution of Civil Engineers: Minute of Proceedings, Vols. LXXI., LXXII., LXXIII.; Charter, By-Laws, and List of Members.

Midland Institute of Mining, Civil, and Mechanical Engineers: Transactions, Parts 64, 5, Vol. VIII.

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Institution of Mechanical Engineers; Proceedings, January, 1883.

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American Society of Civil Engineers: Transactions, April, and June, 1883.

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South Wales Institute of Engineers: Transactions, No 4, Vol. XIII.

Institution of Mechanical Engineers, London: Proceedings, April, 1883.

American Society of Mechanical Engineers: Transactions, Vol. III., 1882.

"Engineering:" Weekly.

The Engineering and Mining Journal: Weekly,

NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES.

Transactions of the AMERICAN INSTITUTE OF MINING ENGINEERS.—Papers read at meetings at Boston and Roanoke, Va. FEBRUARY AND JUNE, 1883.

NATURAL COKE OF CHESTERFIELD COUNTY, VA., by R. W. Raymond, Ph. D.,—"A substance used for domestic purposes, and said to burn like anthracite." From the analysis it seems to be similar to the blind coal of Scotland; and although the section of the seam given shews 90 inches of "Whin Rock" above the coal, and "Thin layers of Whin Rock occasionally" below it, the writer says, that among the samples of country rock sent him, there was no eruptive rock, and seems to doubt the generally accepted view that this substance is due to the coking of the original seam by the intrusion of igneous matter.

THE BOWER-BARFF PROCESS, by A. S. Bower, is a very readable history of the origin and development of the process of coating iron with magnetic oxide for the purpose of protecting it from rust. The writer gives a sketch of the furnace employed and thinks the process has now arrived at the commercial stage; and mentions that a Glasgow firm, Messrs Walter Macfarlane & Co., whose output amounts to 100 tons of ornamental casting per day, have adopted the process.

THE METHOD OF COLLECTING FLUE-DUST AT EMS ON THE LAHN, by T. Egleston, Ph. D., is a full description of the experimental works and results leading up to a process, patented in the name of the Ems Lead and Silver Works, for improvements in the method of condensing and collecting the large per centage of lead which is volatilised in lead smelting. It practically consists in increasing the surface with which the fumes come in contact by hanging sheet iron partitions in the flues. The investigation has been carried out in the elaborate manner characteristic of continental engineers; and the paper is illustrated by plans and a diagram

THE LANGDON GAS-PRODUCER, by N. M. Langdon, is a concise description, illustrated by a sketch, of an experimental gas-producer for supplying gaseous fuel for metallurgical purposes, from both anthracite and bituminous coal and coke dust.

THE BLAST FURNACE OF CROZER STEEL AND IRON COMPANY AT ROANOKE, VA., by J. P. Whiterow. This is a practical paper on a recently erected blast furnace operated by Whitwell fire-brick stoves. A plan of the general management of the necessary plant is given; also formulæ for blast furnace boilers and blowing engines, and some notes on the blowing in.

LEACHING GOLD AND SILVER ORES IN THE WEST, by T. Egleston, Ph. D. This process of lixiviating ores which do not contain enough either of lead or copper for smelting, and which are poor both in silver and gold, is practised in Lower California and Nevada, where an ore containing at the most 0·17 per cent of silver, and full of impurities, is leached with hyposulphite of soda. Each step in the process, from crushing the ore to melting for bullion, is clearly described; and the cost is given in detail.

THE DIVINING ROD, by R. W. Raymond, Ph.D.—A historical and philosophical paper on this old but (as incidents mentioned as occurring in America, of all places in the world, shew) not obsolete method of mineral search.

J. G.

In the TRANSACTIONS OF THE CIVIL ENGINEERS, VOLUME LXXII., PART 2, 1882-83, we find the INAUGURAL ADDRESS of Mr Brunlees, the President. He

gives a short account of the most important engineering works in progress throughout the world, and alludes to the progress made in lighting, as applicable to lighthouses. He also treats of the progress of railway construction in America, China, and the Colonies; and shews the serious inconvenience likely to result in Australia from the adoption of many different gauges on the public lines, four different widths having been laid down, from 3ft. 3½in. to 5ft. 3in. At the conclusion, he makes what seems a valuable suggestion, that, by increased attention to and improvement of our canals in respect of locks and speed of traction, the inland navigation might be brought to compete with and relieve our overburdened railway system in the transport of goods and minerals.

Wm. Anderson, M.I.C.E., describes the ANTWERP WATER WORKS, by which a very impure water is delivered as a pure potable water to a city of 200,000 inhabitants. Special precautions are taken; but, chiefly, "Spongy Iron" is employed as the filtering agent. It is not shewn what this spongy iron is; but it is said that it has the effect of destroying the organisms in impure water likely to cause zymotic disease.

John Fernie has a paper on "MILD STEEL FOR LOCOMOTIVE FIRE BOXES," and brings out very striking differences in the practice and experience of American and English locomotive builders. The subject is exhaustively treated in a long discussion, in which authorities in the constructive employment of steel and iron freely engage.

Amongst the SELECTED PAPERS, the most important are WIRE ROPE STREET RAILROADS IN SAN FRANCISCO AND CHICAGO, by Wm. Morris; TESTS OF RIVETED JOINTS OF STEEL PLATES FOR BOILER WORK, by C. H. Moberly; MINERS' SAFETY LAMPS, by J. B. Marsaut; STEAM IN LOCOMOTIVE CYLINDERS DURING EXPANSION, by D. K. Clark. All these papers have special features of interest. G. B. B.

In ENGINEERING for July and August, Nos. 914-919, a series of papers is given in which, reversing the usual process, history is written before the event. The writer exercises the prophetic spirit in foretelling the disasters which befall the British Fleet in 1886, and if not then, at some other date not specified. The papers are meant to show what the writer conceives to be ERRORS in DESIGN and MANAGEMENT of WAR SHIPS.

No. 915 continues notice of exhibits at Engineering and Metal Trades Exhibition.
J. H.

The AMERICAN ENGINEERING AND MINING JOURNAL, for July and August, contains several papers of interest to members of the Institute.

No. 26.—A Paper "ON A NEWLY DISCOVERED VARIATION IN THE EFFECT OF PROLONGED STRESS ON IRON." The results of some experiments are given and more promised. These shew that iron wire, loaded with considerably less than breaking strain, undisturbed and protected from oxidation by painting, breaks in a surprisingly short time. They also shew much in favour of unannealed as compared with annealed wire.

No. 2 and 3, Vol. XXXVI.—"THE PRODUCTION AND UTILIZATION OF GASEOUS FUEL IN THE IRON MANUFACTURE."

No. 3.—Note relating to "WATER HAMMER IN STEAM PIPES." The result of a few tests to ascertain pressure which had fractured steam pipes—the effect of the peculiar shock when steam admitted to pipes meets cold water therein: technically called "Water Hammer." J. H.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 27th SEPTEMBER, 1883,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

JAMES M'CREATH, Esq., President, in the Chair.

Forty-five members were present.

The minutes of the last General Meeting were read by the Secretary and confirmed.

The following gentlemen, who had been duly nominated at a former meeting of Council, were elected by ballot, and admitted as Ordinary Members :—

ROBERT JACK, Bank of Scotland, Motherwell.

JAMES THOMSON, Meldrum's Mill, Dunfermline.

JOSEPH COCHRANE, Newton Colliery, Newton.

ROBERT DONALD THOMSON, Dalzell Colliery, Motherwell.

DISCUSSION OF THE SECRETARY'S NOTES ON THE FLEUSS LIFE-SAVING APPARATUS AND LAMP.

The PRESIDENT having introduced the discussion on this subject,

Mr JAMES SMART said he expected the business before the meeting was to take into consideration whether it was necessary that they should recommend this apparatus for adoption in Scotland. The first question they might ask was—Was there any necessity for such a thing? So far as his experience went, he must say he had never seen nor heard of an instance where it could have been of much practical use. There might be some gentlemen present who had had extensive explosions, and who might state if such an apparatus would have been serviceable in the restoring of the workings. So far as the life-saving apparatus went, he did not think it could be very applicable to colliery workings. It was invented for the purpose of walking through carbonic acid gas after an explosion. He was, however, of opinion that where carbonic acid gas was so bad that a lamp would not burn, and men could not travel, there would not be much hope of those dressed in the Fleuss Apparatus saving any poor fellows who might be inside. According to all accounts, there seemed to be a good deal of difficulty in the working of the apparatus even supposing they had it. They might have men thoroughly instructed as to its use who would be entire strangers to the colliery to which it was to be applied, and unless they were thoroughly conversant with the workings it was not very likely that they would be of any use in restoring the ventilation or saving life. Therefore, he thought the first thing was to inquire if there was any necessity for such a thing.

The PRESIDENT asked if there was any member who had had experience of explosions or the opening up of collieries after being fired. Perhaps they might give their opinions on the matter.

Mr ROBSON said—In one instance at any rate of which he remembered, this apparatus, had it been in the hands of persons trained to its use, might have been of benefit. This instance was where men were shut in and eventually rescued, but only at

a great risk, as some of the explorers were actually carried out almost in an unconscious state. Of course, he could only speak from what he had read of the apparatus; he had had no experience of it whatever.

The SECRETARY said, judging from the description that was given, the apparatus seemed capable of doing good work in proper hands. The difficulty of course was just to get the proper hands on the spot at the proper time. However, it did not seem to be an intricate apparatus. The introduction of any apparatus was attended with more or less difficulty; but he thought that after a little time there would not be any difficulty in an ordinarily intelligent man making effective use of this appliance. And it appeared to him that the difficulty which had been suggested by Mr Smart might be overcome if the apparatus were taken from colliery to colliery and the method of its working shown to the officials. It was not necessary, he would suppose, that all those who went down the pit invested with it should have been thoroughly experienced in its use. If they had one or two experienced in it to accompany one or more of the officials of the colliery, the difficulty might be overcome,—that was, there would be at least one in the party who would be familiar with the workings. It was quite evident that one single person could be of little use unless there were but one person to rescue. Consequently, if the apparatus was to be effectively applied in the case of men who were in carbonic acid, it must be by several going in.

The PRESIDENT said he thought this was a very valuable paper which they had had from their Secretary. The information seemed to be as full as it could be, and it was well worthy of consideration whether there should be some station where the apparatus might be kept. He thought it might be of use, not only in saving life, but in ascertaining the state of some part of the waste that might happen to be on fire, and closed up for some time. They could get in much more quickly, and before the air would have raised the heat to such an extent as probably to cause another explosion. It did not appear to him that the apparatus was quite so simple as it appeared to the Secretary. It was complicated, and he did not see very well how they could make it

any simpler. The use of it must certainly be attended with a great deal of risk to the man who works it; and, upon anything going wrong, he would be at once killed.

The President then closed the discussion by moving a hearty vote of thanks to the Secretary for the notes he had prepared on the subject, which was awarded.

DISCUSSION OF MR BEITH'S PAPER ON EXPERIMENTS WITH FORCING AND EXHAUSTING FANS.

After the President had formally introduced this discussion, the Secretary read the following communication from Mr J. H. RONALDSON:—

In his notes on these experiments, the author expresses his conviction that the forcing arrangement of fan gives a better result than the exhausting fan. As to whether the results obtained would lead him to a similar conclusion if the fans were placed under conditions the same in every way, it is needless to venture an opinion; but, as far as may be judged from the experiments, these two fans seem to show a marked disregard for at least one of the laws which centrifugal fans usually observe.

The volume yielded by a fan is proportionate to the speed of rotation; and the W.G. to its square. In the following table, constructed from Mr Beith's experiments, it is seen that the volumes at the different speeds stand approximately to one another as the rule would lead us to expect; but a like agreement is far from being found between the observed W.G. and the W.G. calculated from the speeds of rotation; or between the former and the W.G. necessary to generate the observed velocity in the air-current arising from the two highest speeds of rotation:—

Revolutions per min.	Observed current in feet per minute.	Observed W.G. inches.	W.G. calculated from No. of revolutions.	W.G. calculated from observed current.
		FORCING FAN.		
20	562	0·15		
40	1030	0·45	0·60	0·50
60	1615	0·70	1·35	1·23
		EXHAUSTING FAN.		
20	463	0·10		
40	939	0·45	0·40	0·41
60	1216	0·60	0·90	0·80

The calculated W.G.'s in the two foregoing tables are based on the observed W.G. given by each fan at 20 revolutions, and can be held to show nothing more than the divergence between the observations and what we ought to look for by calculation.

The difference is most marked in the case of the forcing fan, and we must infer that there has been either some error of observation, or some other important and unnoticed influence at work during the experiments.

Though it may be a little beyond the comparison at issue, it is not uninteresting to notice the "manometric efficiency" of the fans or the power they show of creating depression or W.G.

"The rule for the theoretical depression, due to the speed of the periphery, is obtained from the law of falling bodies, and is in a perfect fan equal to *twice* the height of column necessary to generate such velocity in a falling body."

Thus $h = \frac{v^2}{32 \cdot 2}$ where h = height in feet, and v = velocity in feet per second.

To convert h into inches of water we have W.G. $= \frac{v^2 \times 12 \times 1 \cdot 2}{32 \cdot 2 \times 1000}$ $= \frac{v^2 \times 0 \cdot 0144}{32 \cdot 2}$ where 1·2 and 1000 are the densities of air and water, respectively.

FORCING FAN.

Revolutions.	Speed of periphery in feet per second.	Observed W.G.	Theoretical W.G.	Manometric Efficiency.
20	20·94	0·15	0·196	0·765
40	41·88	0·45	0·784	0·570
60	62·83	0·70	1·765	0·395

EXHAUSTING FAN.

20	20·94	0·10	0·196	0·510
40	41·88	0·45	0·784	0·573
60	62·83	0 60	1·765	0·311

From the above, it seems probable that natural ventilation was assisting the forcing fan to some extent, and the exhausting fan also, but to a smaller degree, as the manometric efficiency drops from the low speeds to the high. A speed of periphery of 20·94 per second seems too low to allow of a trustworthy comparison of results.

The "manometric efficiency" at 60 revolutions (0·395 and 0·311) is extremely low, and points to some defect in the fans or in their placing, as an ordinary Guibal fan with an expanding chimney gives at least 0·65.

The Secretary also read the following communication from Mr HASTIE :—

In looking over Mr Beith's valuable paper on ventilation, comparing the exhausting with the forcing fan, I observe that he gives a very decided opinion in favour of the latter. This is a very important point to engineers and others who may be erecting fans, and should be well considered by the members of this Institute, so that all the information may be got on it. In my opinion, the length and breadth of the several aircourses and other things may have something to do with the results obtained in the experiments made. I note that with the forcing fan the experiment was made in the tunnel before the air entered the downcast shaft. There would be some escape at this point. The air then travelled in two lines 2460 yards with aircourses having an area of 60 square feet, where it reaches the 11 feet circular upcast shaft. If the air was taken at this point it would give the actual work done in this mine. In the case of the exhausting fan, the air enters the downcast shaft and travels in four lines 2271 yards, with aircourses having areas of 50 and 40 square feet, to the upcast shaft, at the top of which in the tunnel the air was taken, which gives the actual work done in this mine. On account of the aircourses here having a smaller area, the fan might not give such good results, or there might be some mistake made in the measurements. And to show that there is actually something in this I may mention that in June, 1879, when the question of ventilation was before this Institute, experiments were made with the exhausting fan as follows :—Drawing from No. 2 pit Backmuir, and the air going its ordinary course throughout the workings, the result at 50 revolutions was a total quantity in the fan tunnel of 86,840 cubic feet per minute, at ·90 water gauge. The paper now read gives at 60 revolutions per minute, with ·60 water gauge, only 66,880 cubic feet per minute, 19,960 feet less with 10 more revolutions. I should like some further explanations on these points before I can arrive at the

same conclusions as Mr Beith has done, namely,—that the forcing fan gives the best results.

Mr SMART said in all systems of mine ventilation the aim was to have as great a difference as possible between the weight of the air in the upcast and downcast shafts. Until about ten years ago there were very few fans in Scotland,—heat was the rarifying power employed to expand the air in the upcast shaft. A large furnace was placed at the bottom for this purpose. This was dangerous, as it frequently set fire to the shaft. To obviate this danger fans were gradually introduced, and as the exhausting fan rarified the air in the upcast, it was generally adopted. Mr Beith in his paper advocated the forcing fan as being the best, and in describing it, at page 137, showed that the extra weight created by the condensing of the air in the downcast was the propelling force. At page 138 he gave the duty of the exhausting fan as creating a vacuum which nature sought to restore. He (Mr Smart) did not think this was quite correct, as there could be no vacuum formed, air being such an elastic body. The action of the exhausting fan only rarified the air at the upcast and rendered it so much lighter than the atmosphere at the downcast. Whatever might be the method of ventilation there was no doubt but that the weight of the air in the downcast was the propelling power. The question was, which was the most effective method of creating the greatest difference between the weight of the column of air in the upcast and downcast shafts. Mr Beith preferred to place the pressure on the downcast shaft, whereby the density of the air was increased, and had endeavoured to show that the forcing fan gave much better results than the exhausting fan. He (Mr Smart) would not for a moment question the results which had been laid before them, as there was no doubt that, with such large airways as they had at the Clyde Coal Co.'s works, it would work very well, but where the airways were small, frequently contracted, and consequently a considerable amount of friction created, he would question very much if the same results would be given. In contrasting the duty of the two fans, there was very little difference in the length of the airways: that of the forcing fan had an average sectional area of 60 feet, while in the case of the exhausting fan for about half the distance in the Ell Coal the average

sectional area was only 50 feet, and for about the other half in the Main Coal only 40 feet. The sectional area of the upcast of the forcing fan was upwards of 96, while that of the upcast of the exhausting fan was only 56 feet. With such differences as these one would have expected much better results than Mr Beith had shown in favour of the forcing fan. There was one other matter that appeared strange to him. Mr Beith stated "that the upkeep of the forcing fan was not a tithe of what it took to keep up the exhausting fan." His (Mr Smart's) impression was that this was contrary to the laws of nature, as the fan driving through the denser air of the downcast must meet with greater resistance than the fan working in the rarified air of the upcast shaft. He would like Mr Beith to explain how the cost of upkeep in the case of the upcast could possibly be so much more, for he had never seen it, and, looking at the thing in a reasonable light, his idea was that the exhausting fan would be easier driven; and, if the same power were applied, the one would last longer than the other.

Mr BEITH said it was six years since the two fans were fitted up at the Clyde Coal Coy's Collieries, and during that time the forcing fan had got, he might say, no overhaul—only bolts put in and screwed up, whereas the exhausting fan had been repeatedly repaired.

Mr SMART—Can you attribute any cause?

Mr BEITH—Not yet; but it is quite possible I may be able to do it in the committee's report.

Mr DRINNAN did not agree with Mr Beith's opinions on the subject of ventilation, but thoroughly agreed with him that the subject was well worthy the consideration of this, or any other Institute, which aimed at improving the ventilation of mines in this, or other countries. The fearful explosions which, despite all their precautions, every now and again carried death and desolation into one or other of their mining communities, were a terrible commentary on their mine ventilation; and as increase of knowledge could only result from increased investigation, they ought to welcome every effort in this direction. Another and very sufficient reason for further discussion of this subject was the great diversity of opinion which existed even among mine

managers with respect to the laws which govern or affect the ventilation of mines. Rarely was the subject introduced without eliciting the most diverse opinions, and this too from men whose information (apart from personal experience) had all been derived from the same sources; who had had the sufficiency of their knowledge attested by Boards of Examination composed of gentlemen whose knowledge of this, and kindred subjects, was supposed to be such, that candidates who satisfied the requirements ought to hold the most identical views on a subject which forms such an essential part of a colliery manager's education. These conflicts of opinion were certainly not calculated to increase respect for Boards of Examination; and when even this Institute was spoken of as existing merely for the purpose of securing large outputs, it was not impossible that Boards of Examination might have it said of them that they were mainly concerned about an output. With respect to the paper before them, he had already said he disagreed with the main principles laid down, and first would take exception to paragraph 3 on page 137, wherein it was asserted that a forcing fan "*forces, or presses weight on the air,*" and thus increases its density. Whether a forcing fan (so called) or an exhausting fan were used, the principle was the same, simply displacement, forming a vacuum more or less perfect according to the perfection of the apparatus; and a portion of the atmosphere was obtained as a moving power. It was altogether a mistake to suppose that air was pressed or obtained additional density by the action of the fan; the force applied simply gave motion to the air, and any increase of density was due to the resistance met with, therefore, the airways being similar, the resistance and, as a matter of course, the density would be the same whether an exhaust or forcing fan were used. In page 138, fourth line from top, he apprehended "upcast" should be substituted for "downcast," and in paragraph 4 on page 137, Mr Beith said—"The work done by the forcing fan is expressed by the friction which it overcomes, etc." There was evidently some confusion of thought here; $k\,s\,v^2$, or the work done, should read—the coefficient of friction multiplied by the rubbing surface, and the square of the velocity in thousands of feet per minute. In 2nd paragraph of page 138, speaking of the

exhaust fan, Mr Beith said—"its work is expressed by the vacuum which it creates," and then went on to say that this was exactly the reverse of the process employed to obtain the same results in the forcing fan. It appeared so evident to him that the processes, and work done, were in both cases the same, that he could not help wondering whether he had understood Mr Beith aright. It was quite true that the vacuum created by an exhausting fan was a measure of the work done, but, as in the case of the forcing fan, $k\,s\,v^3$ was also a measure of the work done by the exhausting fan; in short, there was in both cases a partial vacuum being created, which the pressure of the atmosphere was constantly seeking to make up, and without which pressure the forcing fan would have no power at all. Looking to the larger area of upcast, and the larger average area of airways connected with the forcing fan, he was not at all surprised that better results were obtained, because, for the same length of airway they had a much diminished rubbing surface, but it was something of a puzzle to him that at 40 revolutions there was the same water gauge in both cases, while at 60 revolutions, taking the pressure in pounds per square foot, it was as 3·6 to 3·1. This lessened pressure quite sufficiently accounted for the lessened volume of air, and he could not account for it otherwise than by supposing that there was some defect in or about the exhausting fan.

The discussion was then adjourned.

EXPERIMENTS WITH FORCING AND EXHAUSTING FANS.

REPORT OF COMMITTEE THEREON.

The Committee appointed by the Council to make further experiments on the Forcing and Exhausting Fans at Townlands and Backmuir Collieries respectively, begs to report as follows :—

The experiments by Mr Beith, as submitted in a paper read

on 16th August, having been made while the fans were working under the ordinary conditions of the respective mines, and opinions having been expressed during the discussion on the paper that a fair comparison of the merits of the fans would result only when they were tested while working under similar conditions, this course has been adopted by the Committee as far as practicable under the existing arrangements at the collieries.

On the 8th September the Committee made experiments at two speeds, viz., 42 and 60 revolutions of the fan per minute. The experiments were repeated on the 11th instant. In each set the quantity of air passing was carefully measured and the water gauge observed, while diagrams of the engines were simultaneously taken by Mr Munro, Engineer, Glasgow.

In the case of the Forcing Fan at Townlands, the covers over the downcast were raised, so that the air which was forced through the tunnel might escape at the top of the shaft. The tunnel is 44 feet in sectional area, and its length, measured from tips of fan to edge of shaft, is 89 feet. It enters the shaft 8 feet below the surface, or 24 feet below top of air-tight compartment.

In the case of the Exhausting Fan at Backmuir, an opening 44 feet in area (the area of the tunnel at Townlands) was made in the mid-wall at a point 7 feet from the surface, so that the fan might get its supply of air at a correspondingly near point. The length of this tunnel is 85 feet, from the edge of shaft to centre of fan, and its area is 55 feet.

In the first set of experiments the area of the Backmuir tunnel was contracted to 44 feet (the area of that at Townlands) by simply fixing a deal on the floor. In the second set a portion of the tunnel 12 feet in length was thus contracted by a wooden floor, and the measurements taken at the middle thereof.

In the first set of experiments the W.G. was observed at the doors leading into the tunnels, which are 29½ and 29 feet distant from the fans at Townlands and Backmuir respectively. These points being relatively distant as compared with the total length of the tunnels, the observed W.G. was in both cases much below that actually existing close to the fans, and the calculated horse-power in the air and percentage of useful effect are correspond

ingly low. In the second set of trials the W.G. was taken 4½ feet from the tips of the fan at Townlands, and 4½ feet from the eye of the fan at Backmuir.

The result at each of the two speeds, and in both sets of trials, gave a larger quantity of air in the Forcing than in the Exhausting Fan, by from 20 to 22 per cent. at 42 revolutions, and from 25 to 29 per cent. at 60 revolutions per minute. The observed W.G., however, was in each case lower in the Forcing Fan, being from 50 to 66 per cent. lower at 42 revolutions, and from 50 to 100 per cent. at 60 revolutions per minute. It is somewhat difficult to account for this great divergence in the respective W.G.'s by any difference in the friction of the tunnels. Indeed, as far as they are concerned, the difference should have operated in favour of the Exhausting Fan, because of the larger area of its tunnel (except for 12 feet), and consequently smaller velocity of air for a given quantity.

The fact, however, remains that the resistance to the air was much greater in the Exhausting than in the Forcing Fan, and thus the otherwise apparent superiority of the Forcing Fan may be entirely due to this alone. We are, therefore, of opinion that much value cannot be put upon the trials, and that the only real test would be to use the same fan—first as an Exhausting and then as a Forcing Fan—to ventilate a particular colliery. If it were considered desirable by the Institute that such a test should be made, a colliery might be selected where the conditions were least variable. The cost of the alterations in changing the inlet would not exceed a few pounds.

Appended is a table giving the results of the experiments.

J. T. Robson.
Robt. Thos. Moore.
Robert Beith.

TABLE

Showing the Results, of Experiments with Forcing and Exhausting Fans At Townlands and Backmuir Collieries.

Date, 1883.		Rev. per Minute.	W. G. at Door. Inch.	Cubic Feet of Air per Min.	Cubic Feet per Revolution	Excess by Forcing Fan.		Horse-Power in Air.	Indicated Horse-Power of Engine.	Percentage of Useful Effect.	Remarks.
						Cubic Feet.	Percentage				
8th Sept.	Forcing Fan, ...	42	+ ·10	66,440	1582	12,232	22%	1·05	8·26	12·7	The percentage of useful effect in these experiments is of no value, in consequence of W. G. having been observed at too great a distance from Fan.
,,	Exhausting Fan,	42	− ·15	54,208	1290	...	...	1·28	8·60	14·9	
,,	Forcing Fan, ...	60	+ ·20	95,040	1584	19,360	25%	3·00	25·69	11·7	
,,	Exhausting Fan,	60	− ·30	75,680	1261	...	...	3·58	24·23	14·8	
			4½′ from Fan.								
11th Oct.	Forcing Fan, ...	42	+ ·30	74,932	1784	12,804	20%	3·54	8·52	41·5	
,,	Exhausting Fan,	42	− ·50	62,128	1479	...	...	4·89	7·17	68·2	
,,	Forcing Fan, ...	60	+ ·61	108,064	1801	24,816	29%	10·38	22·09	46·9	
,,	Exhausting Fan,	60	− 1·25	83,248	1387	...	...	16·40	21·21	77·3	

YOUNG & BEILBY'S PROCESS FOR THE TREATMENT OF COAL.

By Mr George Beilby.

The objects aimed at in the process to be described, are :—

(a) To recover the volatile products of the distillation of coal.

(b) To treat the residual coke for the recovery of its nitrogen as ammonia.

(c) To produce gaseous fuel.

The special points of novelty in the new system, are :—

(d) The 'Incineration Method' of producing ammonia from the nitrogen of minerals containing organic remains.

(e) The simultaneous attainment of the three objects before named.

(f) The apparatus for carrying out the processes.

To enable us to grasp firmly the whole subject, let us first pass in review the main facts of the industrial application of (1) Destructive Distillation, and (2) of Fuel-Gas Making.

DESTRUCTIVE DISTILLATION *(Section a)*.

Destructive distillation is defined by Dr. Mills in his little book on the subject as "the decomposition of a substance in a close vessel in such a manner as to obtain liquid products." He goes on further to say "by a product is meant a body not originally present in the substance distilled." We may modify this definition to suit the present application, and say that coal is distilled destructively when it is heated, either by external heat applied through the walls of the containing vessel, or by its own partial combustion within the vessel, so that certain new substances—solids, liquids, gases,—pass away as vapours and gases, leaving behind a residue or coke, containing carbon and certain mineral constituents of the coal. When it is desired to collect these products, the gases and vapours are cooled so that the condensable portions are brought into the solid or liquid state. But destructive distillation goes on most frequently in circum-

stances where no attempt is made to collect those volatile products. When the open-top blast furnace, the steam-boiler furnace, or the ordinary house fire is freshly charged with coal, the rush of yellow flame, or the volumes of brown smoke given off, indicate the passing away of the volatile products of the coal. Whenever raw coal is burned, it is necessarily also distilled; but in the open fire or furnace the products of distillation are almost immediately brought in contact with a full supply of air and burst into flame, so that they are burned into carbonic acid and water. The Paraffin Oil, Illuminating Gas, and the Coke Making industries are based on the destructive distillation of coal or coal-like minerals. In the two first the object chiefly sought after is the obtaining of the volatile products—paraffin, paraffin oil, and ammonia in the one, and illuminating gas, tar, and ammonia in the other. In the coke making industry, the primary object is to obtain a maximum yield of dense coke—the residue—not the volatile product of the distillation. These three applications of destructive distillation depend for their important differences partly on the nature of the material distilled, but very largely, also, on the temperature at which the distillation is carried on, and on the way in which the heat is applied. The paraffin industry is called "The Low Temperature Industry." In it a low red heat is gradually applied to the material, and thereby a maximum yield of paraffin and olefin hydro-carbons is obtained. The illuminating gas industry is called "The High Temperature Industry." In it a bright red heat is suddenly applied to the material, and thereby a maximum yield of incondensable gas of high illuminating power, and a tar containing hydro-carbons of the Benzine, Authracene, and Napthaline series are obtained. Submitted to these distinct processes, the same raw material will give those widely different products. In both cases a yield of ammonia corresponding to from $\frac{1}{5}$ to $\frac{1}{10}$ of the total nitrogen of the material is obtained. As far as its position can be properly assigned, the coke making industry takes a place intermediate between the high and the low temperature industries. The volatile products collected from bee-hive and other ordinary coke ovens have a general character which classes them between paraffin oil on the one hand, and gas

tar on the other. This arises probably from the mode of applying the heat rather than from the temperature itself. A high temperature is *gradually* applied to the coal, so that paraffin products are made at first, and intermediate and gas tar products as the process goes on. The yield of coke is increased, and its quality is improved by allowing the oil or tar vapours to pass through the red hot coke. If hydro-carbon vapours are passed through red-hot coke, they deposit some of their carbon in the pores of the coke, enriching it at their own expense. The impoverished gases will thereafter yield a much smaller return of condensable hydro-carbons, and the incondensable gas has a very low illuminating value. Apart from such a system as is here indicated the yield of coke would be from 10 to 15 per cent. lower. For these and other reasons, processes for the recovery of volatile products from coke ovens have hitherto met with no general acceptance. The coke maker, without necessarily knowing why, theoretically, it should be so, was fully aware that if he attempted to take away volatile products, the coke at once failed to satisfy its consumers, the iron makers, and others. And there has been a further obstacle; he has always been met by the necessity for an increased expenditure on plant and a heavier cost in handling the material.

There are at present before the Coal and Iron Trades of the North of England two systems, both claiming to solve the problem of the production of a first rate coke with the recovery of the volatile products of the process. By the '*Jameson System*' exhausting and condensing plant is adapted to the existing bee-hive ovens, so as to draw away the products at the floor level. It is claimed that this in no way interferes with the quality and quantity of coke obtained, and that the oils, tars, and sulphate of ammonia repay the extra costs, and leave a margin of profit. Similar advantages are claimed for the '*Carvès Ovens*,' which have been modified by Mr Simon of Manchester. But in their case, new and special plant is erected at considerable cost, so that large yields of more excellent products might fairly be expected. Small coal is closely packed in long, deep, but narrow, horizontal retorts or ovens, and the application and command of heat more nearly resembles that of the gas retort,

the heating being entirely through the walls of the oven. The coke is discharged from the ovens by a travelling ram, which pushes the solid block of coke out into a hutch.

These systems are at present on their trial in England, and if of genuine value are certain soon to come into extensive use.

The Scotch Iron Trade has for more than two years been much interested in the application of condensing and scrubbing appliances for the recovery of tar and ammonia from the gases of blast furnaces. Published reports indicate that the Messrs Baird and others have met with considerable success in this application. The enormous cubic content of the blast furnace, and the set of conditions necessarily involved in the successful production of iron, are hardly compatible with the other set of conditions most favourable to carrying out the distillation of coal for making and recovering products; nevertheless these systems will evidently exercise a most important influence on the iron trade of the country.

In the sketch thus lightly given of systems for the application of the process of destructive distillation with condensation of products, to the coke and iron making industries, no attempt has been made to enter into them in such a way as it would be necessary to do if full justice were to be done to the men whose skill and perseverance have brought the systems into their present prominence. Full accounts of certain of these systems have already been published by the authors or by others, and to these all persons interested will naturally turn.

To complete these introductory remarks it remains to notice

THE FUEL-GAS INDUSTRY *(Section e)*.

The gasification of carbon and the use of the gaseous fuel so produced for heating purposes in metallurgical and chemical operations is a matter about which something is known by most engineers and manufacturers. But while a general acquaintance with the subject is common, a more exact knowledge of the principles involved in the various practical applications, is not by any means so general.

That coal, when burned in a close chamber with admission of

air insufficient for its complete combustion into carbonic acid, gave a gas containing hydrogen, hydro-carbons, and a large percentage of carbonic oxide, was known for a very long time before any practical application of the knowledge was made. In due time, however, the necessities and demands of the metallurgical industries called to the front the man, in the person of Dr—now Sir William—Siemens, who by applying the principle of '*Regeneration*' or heating of the in-going combustibles, air and gas, by the out-going products of combustion, by passing them alternately through the same stacks of brickwork, initiated a new epoch in the use of gaseous fuel, and opened up to the metallurgist possibilities before undreamed of. The high and uniform temperatures attainable by this system caused its use to spread from one industry to another; and the last ten years have seen it applied to illuminating-gas making, to glass making, to brick making, and to alkali making, as well as to its original use in steel making.

In most of the gas producers now in use, raw coal is distilled and partially burned into carbonic oxide by the regulated admission of air into a brick-lined, iron-jacketed combustion chamber. The rough gas so produced is led away in iron mains so disposed as to insure the cooling and partial condensation of tars, after which it is taken through the regenerative apparatus to the point at which it is to be burned. The gas produced generally contains—

Carbonic Oxide, - - - -	33 per cent.
Carbonic Acid, - - - -	2 „
Hydrogen, - - - - -	5 „
Nitrogen, - - - - -	60 „

By the saturation with water of the air entering the producer, a small percentage of hydrogen is added to the gas, from the decomposition of the water in contact with red hot carbon. Steam is sometimes blown into the bottom of the producer, partly with this object, and partly also to cool the lower part of the producer to prevent the running of the coal ash into clinkers.

In gas works, when the retort settings are fired with gaseous fuel, the freshly-drawn and red-hot coke from the retorts is raked into producers within, or immediately in front of, the bench. In

these producers it is partly oxidised or burned, giving a gas rich in carbonic oxide; and, by the use of water or steam, a percentage of hydrogen is added. The marked differences between the two systems are:—In the first, raw coal being used, products of distillation are found in the gases, and certain of these, viz., the tars, which are liable to choke the flues and gas passages, have to be separated by cooling the gas after it leaves the producer and before it enters the regenerators and combustion chambers. Nearly the whole of the heat of the primary combustion of the carbon is lost in this way. In the second system, the coke having already parted with its volatile products, there are no tars in the gases, which can, therefore, be led, still hot, into the combustion chamber; and so the greater part of the heat of primary combustion is saved. Further, as in the second system, the producer has only one office to perform—viz., to burn carbon into carbonic oxide—it can do its work much more easily and quickly than the producer in the first system, which has to distil off the volatile products as well as to gasify the carbon. Yet, further, when raw coal is used, the softening or intumescence of the bituminous portions makes it necessary to break up and poke the mass in order to keep it working regularly. In the coke producer, this is not necessary; if properly constructed, it may be undisturbed for 10 or 12 hours.

The third system for the production of heating gas is the '*Water Gas System.*' 'Water Gas' is produced when steam is passed through red-hot carbon. The water parts with its oxygen to the carbon forming carbonic oxide, and hydrogen is set free. The resulting gas consists of equal volumes of hydrogen and carbonic oxide, the former with a heat value of 34,000, the latter with 2400 heat units per pound; its value is, therefore, very high. In this system it is very desirable to keep the reaction between the water and the carbon on the lines indicated, and to avoid, as far as possible, making carbonic acid, which has no heating value, and would only dilute the gas. This is attained by keeping the temperature of the coke high, and by avoiding the presence of any excess of steam over that necessary for the carbonic oxide reaction.

Many proposals have been brought forward to manufacture

this gas, chiefly with the intention of enriching it with hydrocarbons to fit it for illuminating purposes. In America this scheme has found some favour, and in a number of important towns Water Gas Companies are formidable rivals of the Coal Gas Companies.

For the manufacture of water gas on a large scale for heating purposes, various proposals have been made. The '*Strong*' and other Systems have been before the public for some time, but the writer is ignorant as to the extent of their success. In general, the plan of manufacture is to have two cupolas charged with coke, one of which is kindled and blown up to a white heat with air. The air is then turned off and steam is passed through the white-hot coke and is decomposed, forming water gas. Meantime, the other cupola is being blown up, and is ready to take the place of the first when its temperature has fallen too low. The two cupolas are thus worked alternately, the one heating up while the other makes gas.

The theoretical results of the three systems of gas making are shown in Tables I., II., III., IV., and V. It is not in the writer's power to present *working results* and figures showing the comparative value of all the systems. A comparison, in which some of the results have been got from practice and others by calculation from theoretical numbers, would be valueless. These tables have, therefore, been drawn up on the same fundamental data, in each case taking the simple chemical reaction uncomplicated by side reactions, and calculating the heat values of the products on the results of scientific determinations of the heat value of the pure substances.

Tables I. and II. show the heat value of a ton of good coke when it is burned directly into carbonic acid, and of the gases made by its limited oxidation in a gas producer; these gases being cooled before their final combustion, so that all of the heat of the primary combustion is lost.

Tables III., IV., and V. show the heat value of a ton of the same coke when it is converted into carbonic oxide by steam.

These five tables will again be referred to when a comparison with the results of the new process is instituted.

THE 'INCINERATION METHOD.' *(Section b.)*

As early as 1871, one of us began an investigation into the history of the nitrogen in shales during their distillation for the production of paraffin oils. The conclusions then arrived at were, that when the temperature of distillation is never allowed to rise above a low red heat, the nitrogen originally present in the shale is all found in the condensable products of distillation and in the carbonaceous residue. In the former it occurs in the watery distillate as salts of ammonia; and in the oil, in basic or alkaloidal bodies. In the carbonaceous residue, a part is found as ammonia occluded in the pores of the carbon, and the greater part is in some unknown way associated with carbon and possibly with hydrogen. Elsewhere, a more detailed account has been published of how these conclusions were arrived at.

Table XII. shows the distribution of nitrogen, which takes place where two different shales are distilled at a low red heat. No. 1 is an East of Scotland shale, a true oil shale situated far below the coal seams. No. 2 is a West of Scotland coal shale, occurring among the coal seams.

Following the newly-acquired knowledge on this subject, attempts were made to increase the yield of ammonia obtained from shales by drawing upon the stores of unused nitrogen in the oils and in the carbonaceous residue. At first the idea of the soda-lime process held sway; and experiments, both on a large scale and in the laboratory, were tried in Oakbank Works. Slaked lime was mixed with the shale in powder, was washed over it like white-wash, was tried in large percentage and in small: the treated shale was distilled in horizontal and vertical retorts, with steam and without; but no increase in ammonia yield was obtained. Certain other very marked effects were produced, but these have no connection with the matter now in hand. At Magdalen Bridge Works in 1873, by the continued application of a low red heat to the shale residue after it had parted with all of its hydro-carbons, steam being passed through the shale, a small additional yield of ammonia was obtained, probably derived from the occluded ammonia of the carbonaceous residue. Table XIII. shows the re-arrangement introduced by this treatment. Investi-

gations were continued; shales, cannel, splint, and bituminous coals all being experimented with, and a mass of facts accumulated. These investigations resulted in the discovery of the exact condition under which the organic matter of minerals can be made to give up the whole of its nitrogen as ammonia.

Contemporaneously, Dr Hubert Grouven of Leipzig discovered the 'Incineration Method,' and succeeded in bringing the process to such perfection that it is now in use as an analytical method for the determination of nitrogen in the laboratory. The process has been fully described by him in a paper contributed to 'Der Laudwirthschaftliche versuchstationen.'[1]

When coke or carbon is burned in steam under the conditions of the 'water-gas process,' one atom of carbon decomposes one molecule of water combining with its oxygen to form carbonic oxide, and setting free one molecule or 2 atoms of hydrogen.

$$C + H_2O = CO + H_2.$$

If the carbon used happened to be a residue from the distillation of some organic matter containing nitrogen, it would contain a certain amount of nitrogen (Table XII.), which, in the above reaction, would be set free as nitrogen gas.

But if, instead of burning the nitrogenous carbon with just sufficient steam to produce carbonic oxide, a large excess is employed, 3 atoms of carbon and 5 molecules of water will give 1 molecule of carbonic oxide, 2 molecules of carbonic acid, and 5 molecules of hydrogen, and the nitrogen combining with hydrogen will be set free as ammonia.

$$3\,C + 5\,H_2O = CO + 2\,CO_2 + 5\,H_2.$$

A large excess of steam is necessary to protect the molecule of ammonia which would otherwise be resolved into its elements, nitrogen and hydrogen, by contact with the highly-heated carbon. Table XIV. shows the application of this process to Nos. 1 and 2 Shales.

Reference to table XII. will show what a large proportion of the original nitrogen of the mineral is ultimately found in the oily distillate. In the coal shale, No. 2, more than a fourth, and

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1 A translation of this paper is published by Morrison & Gibb, Edinburgh.

in certain coals, and in peat, even a larger proportion is so found. Much thought and experimenting had been given to the solution of how to obtain this nitrogen as ammonia, but with only partial success, till Dr Grouven succeeded, first in the laboratory, and ultimately on the large scale in his works at Bürgerhof. To accomplish this, he passes the alkaloidal vapours together with excess of steam over a very porous clay-lime silicate, kept at a temperature somewhat below the melting point of copper; by this treatment these complex vapours are resolved into ammonia, carbonic oxide, carbonic acid, and hydrogen.

In working out an economical process based on these discoveries, we have found that a certain amount of air may be used along with the steam for the incineration of the carbon without seriously reducing the yield of ammonia. The proportion of air which may be safely used varies with the material operated on; in some cases, two, or even three times as much air may be used, as in others.

In many cases this use of air introduces a decided economy, saving steam, and also the application of external heat. On the other hand when a proportion of air is used, the heating gases produced are diluted by its nitrogen.

Tables VI. VII. VIII. show the weights, volumes, and heat values of the gases produced by the complete incineration of the carbon of one ton of coal by excess of steam; also, a comparison is drawn between the heat value of the original coal and of these gases. In these and the three following tables the composition of coal is taken from a table in Ronalds & Richardson's Technology, which gives the average analysis of a number of samples of Scotch coal. With one exception the figures in that analysis call for no special remark. The exceptional item is the nitrogen, which is placed at 1 per cent. This is too low. The writer has had very many samples of all kinds of Scotch coal analysed, but has never seen any with such a small percentage; $1\frac{1}{2}$ per cent. would be more nearly the truth.

Tables IX. X. XI. show the same details as the previous three, but worked out for a case when only one half of the carbon of the coal is incinerated with steam. The significance of this will appear later.

THE PRACTICAL PROCESSES AND APPARATUS.

(Sections e and f.)

As stated at the outset, the objects of the new process or system are—

(*a*), To recover the volatile products of the distillation of coal.

(*b*), To treat the residual coke for the recovery of its nitrogen as ammonia.

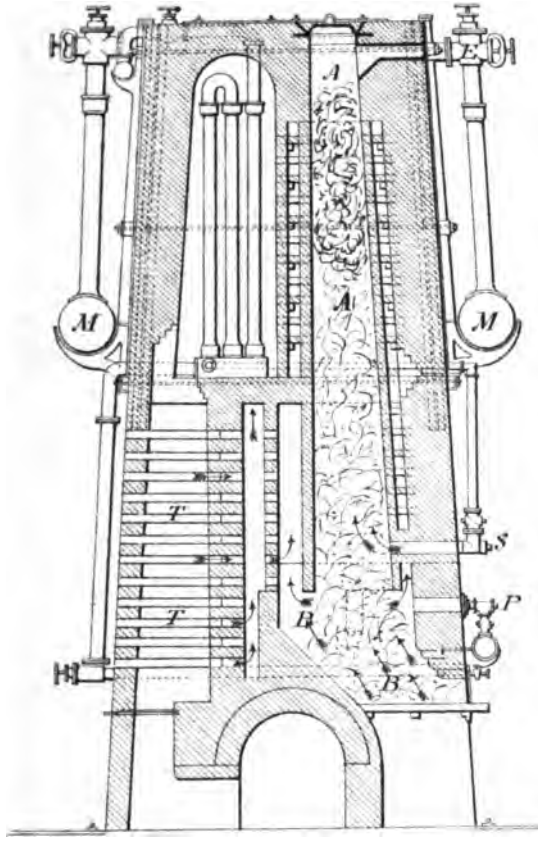
(*c*), To produce gaseous fuel.

Keeping these points in mind it will be seen how far in the practical applications of the process we have succeeded in attaining these objects profitably. Two forms of coal retort will be described. The first is in use in the Clippens Oil Coy.'s Works at Pentland. The second is being erected in the Oakbank Oil Coy.'s Works at Mid-Calder; its present form having been evolved through a series of experimental retorts erected and worked in both of these works.

Fig. I. shows a retort bench of the first form in cross section. The retort *A* is built of square fire-bricks 3 inches thick; its walls, though strongly tied into the surrounding brickwork, are fully accessible to the hot furnace gases which pass round it on all sides, and keep it at a bright red heat. Instead of a close door or water lute closing its lower end, the retort terminates in a combustion chamber *B*, provided with heavy furnace bars, a cleaning door, and an ashpit. The residual cinder coke is consumed in this chamber with a limited supply of air, so as to produce carbonic oxide. This gas passes through ports into the flue space surrounding the retort, where it is met with a supply of heated air, which enters through the regenerator *T T*, sufficient to burn it into carbonic acid, and thus produces heat enough, not only to distil and partly incinerate the coal; but also to heat other retorts (as at Pentland), or furnaces for metallurgical or chemical operations. Coal is charged into the retort through the door on the top in quantities of 5 to 7 cwts. at a time. The products of distillation and incineration pass away by the top exit pipe *E* into a main *M*, from which they are led through condensers and scrubbers. Steam is passed into the lower part of the retort at *S*, and is

To illustrate Mr GEORGE BEILBY'S Paper on "YOUNG & BEILBY'S PROCESS FOR THE TREATMENT OF COAL."

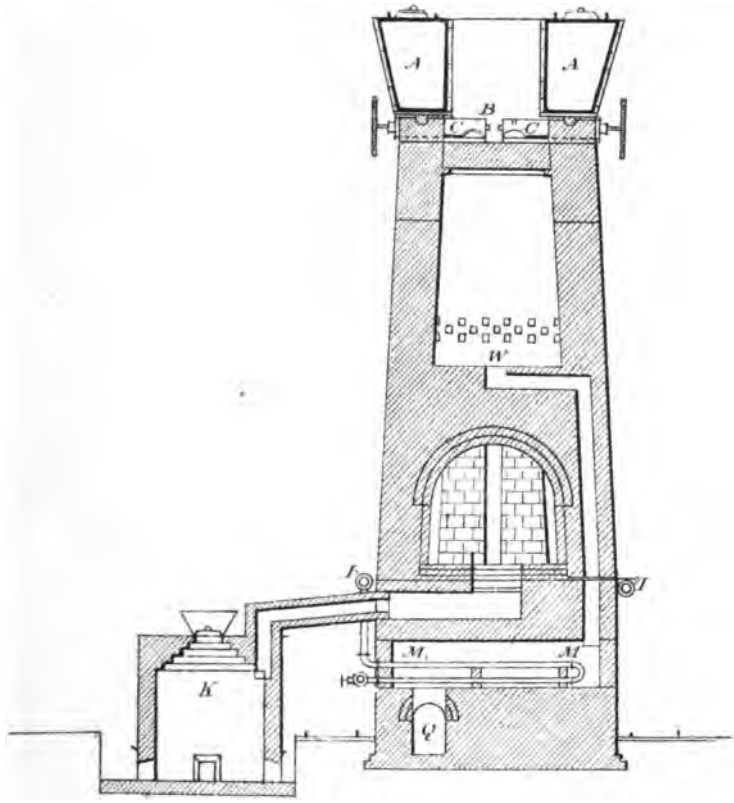
FIG. 1.



Scale $\frac{1}{8}$ inch to 1 foot.

To illustrate Mr GEORGE BEILBY'S Paper on "YOUNG & BEILBY'S PROCESS FOR THE TREATMENT OF COAL."

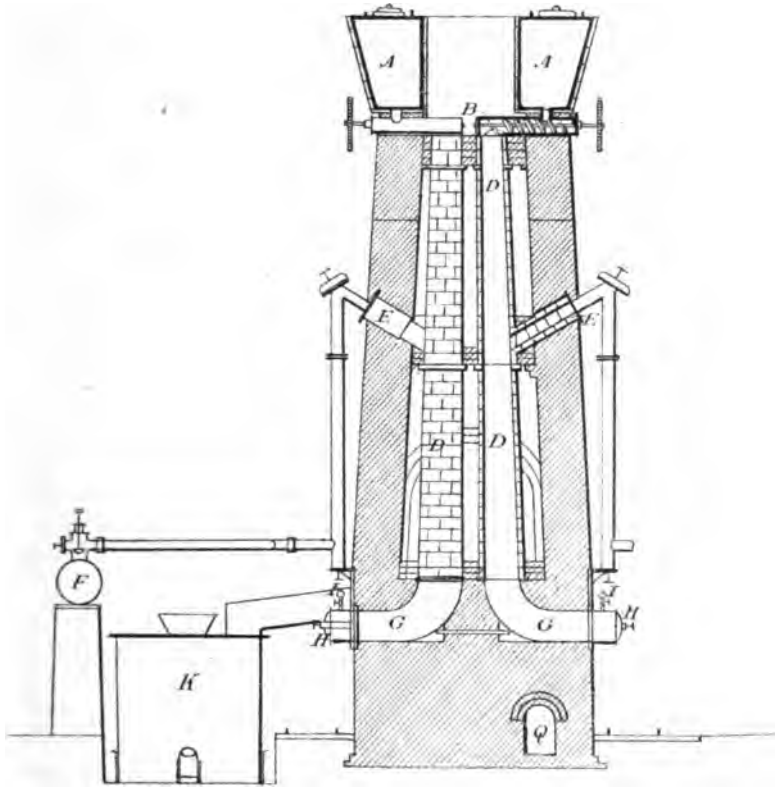
FIG. 2.



Scale ½ inch to 1 foot.

To illustrate Mr. GEORGE BEILBY'S Paper on "YOUNG & BEILBY'S PROCESS FOR THE TREATMENT OF COAL."

FIG. 3.



Scale ⅛ inch to 1 foot.

decomposed as it passes up through the brightly-ignited coke. As only sufficient air is passed into the combustion chamber to form carbonic oxide, no excess of air can pass up through the actual retort; but to make assurance doubly sure, some of the permanent combustible gas is returned from the condenser and is passed into the retort at a point *P*, below that at which the steam pipe enters. This gas would effectually arrest and combine with any air which had escaped through the coke.

At Pentland Works all the retorts used for distilling shale are heated by means of these coal retorts. Through the kindness of Mr Bell, manager of these works, the following note of results obtained there have been got. For the month of August the average yield of sulphate of ammonia from the dross used in the retorts, was 45·75lbs. per ton. In addition, 10 to 12 gallons of tar are obtained. No direct measurements of the heating value derived from the coal can be made; but the work done in distilling shale indicates a most economical use of the fuel in this system; for while in Oakbank Works similar shale retorts fired with raw coal in open furnaces required 2·9 cwts. of coal for every ton of shale distilled, these gas-fired retorts at Pentland only require 1·1 cwts. of coal per ton of shale. It is evident, therefore, that the recovery of 45lbs of sulphate of ammonia and 10 gallons of tar has been accomplished with a very large actual saving of heating power.

With this apparatus it may fairly be claimed that the three objects aimed at have been attained.

Figs. 2 and 3 show two cross sections of a setting of 12 coal retorts which are at present being erected at Oakbank Works.

Dross is emptied from the hutches into the oblong iron hoppers *A A*. Each hopper holds coal for three retorts. The dross is slowly fed into the retorts by the feeding screw *B*. The iron cover *C* is provided with a two-inch plug-hole, also with an eight-inch door, by removing one or other of which the state of the material inside the retort can be inspected, and a rod or poker introduced when necessary. The retorts *D D* are of oval cross section, built of grooved and tongued bricks, 3 inches thick. An exit pipe *E* passes off at the centre of the retort. This is a

brick tube made in short lengths and covered with an iron sleeve piece, by which it is connected with the main *F F*, which in turn is connected with the necessary condensers and scrubbers. At its lower end the retort is built upon an iron snout piece, *G G*, which passes through solid brickwork to the outside of the building, where it is closed by an iron or steel door, *H H*. Steam, superheated by passing through cast-iron pipes *M*, heated by the spent furnace gases, is led into the snout piece behind the door *H* by the pipe *I*. The twelve retorts are heated by a coke gas producer *K* placed in front of the setting. In this producer a certain quantity of the cinder drawn from the retorts is made into carbonic oxide, which is conveyed, still red hot, into the combustion chamber, where, meeting with a supply of air brought from the outside by a separate channel, it takes fire, the flame of hot gas dividing, one-half passing round six retorts to the right, the other half round six retorts to the left. The flame travels along the lower halves of the retorts, turns and comes back at the high level along the upper halves, then passes away through a number of small pigeon-holes into the drop *W* to the main flue *Q*, passing on the way over the steam heating pipes *M*. The upper half of the retort is kept at a good red heat. It is about three-quarters filled with coking or freshly-coked coal, which is fed in by the screw at from half a pound to a pound per minute. In this part of the retort the coal parts with all its volatile matter, but is not subjected to a temperature high enough to destroy the ammonia-forming nitrogen of the coke. In the lower half the heat is maintained at the incinerating temperature, and a full current of steam passes upward through the perfectly loose and free coke. Here the carbon may be wholly or partially burned, the amount of incineration being determined by the length of time the coke is left in the retort. The coal-feed is regulated by the speed of the screw which can be varied at will. Coke, half-burned cinders, or simply ashes may be removed by the door *H*.

The proper paying point to which incineration should be carried must be determined for each kind of coal, as it will vary with local circumstances. The results obtained in working the experimental retorts similar in construction to those shown, pointed to the following as the best paying system of working :—

From 1 Ton of Dross—

4 to 5 gallons of good Gas Tar, worth, say, 2½d per gal. -	10d.
80 lbs. of Sulphate of Ammonia, worth, say, 1d per lb. -	80d.
91,000 cubic feet of Heating Gas (Table IX.), 8 Cwts. of Cinder (Table IX.) - - - -	40d.
	130d.

The last two items are valued as yielding 80 per cent. of the heating power of the original coal.

At first it was feared that the small coke or 'cinders' resulting from the partial incineration of dross would be of no value; but after a few trials, it was found to give most excellent heating results when used in gas producers of the simple construction shown on Figs. 2 and 3. One of these has been in use at Oakbank for more than three months, and its performance has far exceeded our expectations. It took the place of an ordinary coal furnace burning two tons of coal a day; and with seventeen to eighteen cwts. of cinders is doing better work than two tons of raw coal. This economy arises from two causes; the combustion of the simple, nearly uniform, gas can be regulated to a nicety by the proper admission of air, and the great loss involved in burning down and cleaning the coal furnace once a shift is avoided.

The abstract of tables I. to XI. inclusive, shows with what economy of heating power the partial incineration process may be accomplished; and the practical results brought forward go far to confirm these theoretical conclusions. But further economy is possible. The figures set forth in tables VII. and X. offer a tempting field for the application of recuperation to reduce to the lowest point the absorption of heat in the process. Special appliances have been designed with this object, and on some other occasion the writer hopes to be able to report as to their practical success.

In studying the figures in these tables and in the abstract, it will be borne in mind that in every case the heating value of the substances has been taken from the results of absolute determinations by the calorimeter, and therefore, that, this value in practical heating operations will be subject to certain deductions according to the nature and physical condition of the products of combustion. Hydrogen, owing to its product being water, is

most seriously affected by such a deduction, because in calorimeter experiments the heat given out by the water in becoming liquid is included in the 34,000 heat units per lb., while in the case of carbon with its 8,080 heat units no such deduction is necessary: because the product of combustion, carbonic acid, passes out of the calorimeter as a gas and retains its latent heat of vaporization. Such a correction as this would reduce the value of hydrogen by 4,800 heat units, and bring it down to 29,200. Again, the loss of heat by the presence, with the combustible, of diluents like nitrogen or carbonic acid has not been taken account of in these tables; the corrections called for in each special case can easily be applied as occasion requires.

GENERAL APPLICATION OF THE PROCESS. *(Section f.)*

To Gas Works.—Bituminous or splint dross will be distilled in horizontal gas retorts at a moderate heat, so as to give 5,000 to 6,000 cubic feet of good gas. By restricting the quantity of gas taken to the illuminating gas mains, and by keeping down the temperature of the retorts, the illuminating power will easily be kept up to twenty-five candles. The coke will be dropped into vertical ovens or retorts, in which it will be partially incinerated, producing an additional yield of ammonia of, say 40 to 50 lbs. of sulphate, 40,000 to 60,000 cubic feet of heating gas, and 6 to 8 cwts. of cinder coke. In situations where a demand exists in the immediate neighbourhood for heating gas to be used for manufacturing purposes, its distribution will be cheap and easy, and the profit from its sale will be handsome. Anything like a general distribution of heating gas through a district is not contemplated in the meantime, but rather the supply of two or three large consumers within a short radius. A neighbouring factory burning twenty tons of coal a day for firing steam boilers, might with great advantage replace the coal by gas supplied from the gas works; sold, not at so much per 1,000 feet, but at a rate per 10,000,000 heat units of value, comparable with the rate formerly paid for the same effective heating power in the form of coal.

The cinder coke after leaving the ammonia retorts will be available for heating the retorts themselves, or for sale.

The products obtained from a ton of good bituminous dross will be :—

5000 Cubic feet of illuminating gas at 1s per 1000, ...	60d
10 Gallons of good tar at 2½d per gallon, ...	25d
70 lbs. of sulphate of ammonia at 1d per lb., ...	70d
Heating gas, Cinder, ... { available to sell at say 50% of original heat value, or 8,000,000 heat units, ...	30d
	185d

Or 15s 5d per ton.

It is evident that with cheap coal and short railway carriage, the margin of profit must be very large.

In Chemical and Metal Works.—For nearly every industrial purpose gaseous fuel is far superior to raw coal or even to coke. For many of these purposes it is at present a necessity, and has to be made in costly plant and with considerable trouble. The new process will supply the very best gaseous fuel at a cost much below that of the cheapest producer gas. The application of coke gas producers in situations where gas conveyed from a distance by pipes is inadmissible, will in itself be a great advantage, supplying as they do clean, smokeless fuel, at a moderate cost.

For certain branches of chemical manufacture an additional valuable product is obtained by the new process, viz., carbonic acid. This gas is extensively used in soda making by the ammonia process. In Dr. Grouven's work at Bürgerhof he combined soda making with ammonia making, and found great advantage in so doing. He claims that he can by his process make 99% soda ash for £2 per ton.

A further use for carbonic acid is found in certain processes for the recovery of sulphur from alkali waste. A reference to tables VI. and IX. will show that the gases from the process contain 20 and 22% of carbonic acid ready for use for any of these purposes.

At Coal Pits.—Many consumers of coal for industrial purposes are so situated that they cannot themselves erect retorts, and distil and incinerate coal. The coalmaster must step in, and by working up his small coal at the pits, be in a position to supply

cinder coke to these consumers at such a moderate price as will tempt them to give up raw coal and replace their open furnaces by coke gas-producers.

The Government are already moving in the matter of a stringent Smoke Prevention Bill; landed proprietors are becoming more and more restive under the destruction of their trees by smoke; farmers in the neighbourhood of factories press their claims for damage done to their crops with increasing urgency; royal personages, medical men, scientific men, artists and philanthropists are uniting their energies to reform the heating of our large cities, so that smoke fogs may be done away with: everything points to a coming reformation which, like other reformations, may either be forced upon us from the outside with all the loss and pain involved in that, or may be heartily taken up and worked from within, outward to the profit and advantage of all concerned.

TABLE I.

Showing the Products of One Ton of Coke, its Carbon being oxidised by Air to form Carbonic Oxide.

COMPOSITION OF COKE.			AIR USED.	PRODUCTS.		Volume of Gases at 16°C.		HEAT VALUE OF THE GAS.	
	Per cent.	Pounds.	Pounds.		Pounds.	Cubic Feet.	Per cent.	Per Pound.	Total Units.
Carbon .	90.	2,016	12,800	Carbonic Oxide	4,704	63,504	31·90	2,400	11,289,600
Ash . .	10.	...	...	Nitrogen . .	10,112	136,512	68·10	...	...

TABLE II.

Showing the Comparative Heating Value of One Ton of Coke, and of the Gases obtained as in Table I.

POUNDS.		HEAT UNITS PER LB.		HEAT UNITS.
2240	Coke	7272	... ...	16,289,280
4704	Carbonic Oxide	2400	... ...	11,289,600
			Loss of heating value by Gasification of Coke, ... Equal to 30·7 per cent.	4,999,680

TABLE III.

Showing the Products of Complete Incineration of One Ton of Coke with Steam not in excess.

COMPOSITION OF COKE.			STEAM.	CHEMICAL REACTION.	PRODUCTS.		VOLUME OF GASES AT 16°C.		HEAT UNITS.
	Per Cent.	Pounds.	Pounds.			Pounds.	Cubic Feet.	Per Cent.	
Carbon	90	2016	3024	$C + H_2O = CO + H_2$	Carbonic Oxide	4704	63,504	50	11,289,600
Ash	10				Hydrogen	336	63,672	50	11,424,000

TABLE IV.

Showing the Heat Units Absorbed in the Complete Incineration of One Ton of Coke with Steam not in excess.

To heat 2240 lbs. of Coke to 500°C,	2240 × ·24 × 500	268,800
To raise 3024 lbs. of Water into Steam at 100°C,	3024 × 620	1,874,880
To heat 3024 lbs. of Steam from 100°C to 500°C,	3024 × ·47 × 400	568,512
Heat absorbed in the reaction $C + H_2O = CO + H_2$	2016 × 3040	6,128,640
To maintain the temperature of the apparatus against losses by convection, radiation, &c.—equal say to 5% of Coke incinerated,	112 × 8080	904,960
		9,745,792

TABLE V.

Showing the Comparative Heating Value of One Ton of Coke and of the Gases Obtained from it as in Table III.

POUNDS.		HEAT UNITS.		HEAT UNITS.	HEAT UNITS.
2240	Coke	7272			16,289,280
4704	Carbonic Oxide ...	2400		11,289,600	
336	Hydrogen ...	34,000		11,424,000	
				22,713,600	
			Deduct heat absorbed as shown in Table IV.	9,745,792	
					12,967,808
			Loss in heat value of 1 Ton Coke by gasification, ... Equal to 20·4.	... ...	3,321,472

Table VI.

Showing the Product of Complete Incineration of One Ton of Coal with Excess of Steam.

Composition of Coal.			Steam Used.	Chemical Reactions.	Products.		Vol. of Gases at 500° C		Vol. of Gases at 16° C.	
	Per Cent.	Pounds.	Pounds.			Pounds.	Cubic Feet.	Per Cent.	Cubic Feet.	Per Cent.
Carbon,	78·53	1758	4395	$3C + 5H_2O$	Carbonic Oxide,	1367·3	52,355	7·54	18,500	11·15
—	—	—	—	$= CO + 2CO_2 + 5H_2$	Carbonic Acid,	4297·3	104,710	15·08	37,000	22·30
Hydrogen,	5·64	126	—	—	Hydrogen,	580·9	311,526	44·82	110,080	66·55
Nitrogen,	1·00	22	—	$N_2 + 3H_2 = 2NH_3$	Ammonia,	26·7	1,678	·24	Condensed.	—
Sulphur,	1·11	25	—	$S + H_2 = H_2S$	Sulphuretted Hydrogen,	26·6	826	·12		—
Oxygen,	9·69	217	—	$O + H_2 = H_2O$	Water,	3760·2	223,468	32·20		—
Ash,	4·03	92	Excess, 3516.	—	Ash,	92·0	—	—	—	—
	100·00	2240 +	7911 =	10,151		10,151·0	694,563	100·00	165,580	100·00

TABLE VII.

Showing Heat Units Absorbed in the Complete Incineration of One Ton of Coal with Excess of Steam.

To heat 2240 lbs. of Coal to 500°C.,	2240 × ·24 × 500°	268,800
To raise 7911 lbs. of water at 16°C. into Steam at 100°C.,	7911 × 620	4,904,820*
To heat 7911 lbs. of steam at 100°C. to 500°C.,	7911 × ·47 × 400	1,487,200*
Heat necessary for the reaction $3C + 5H_2O = CO + 2CO_2 + 5H_2$	1758 × 1875	3,296,250
To maintain the temperature of the apparatus against losses by convection, radiation, &c.—equal say to 5% of Coal incinerated, or	112lbs. Carbon × 8080	904,960
Total heat units required, ...	... ...	10,862,030

* By suitable regenerative condensers a large proportion of this heat may be recovered.

Table VIII.

Showing the Comparative Heating Value of One Ton of the Original Coal, and of the Gases Produced by its Complete Incineration with Excess of Steam, deducting from the latter the Heat Absorbed in their production.

Pounds.		Heat Units per Lb.		Heat Units.	Heat Units.
2,240	Coal.	7,000	... ...	... ...	15,680,000
1,367	Carbonic Oxide .	2,400	... ...	3,280,800	... ...
573	Hydrogen . . .	34,000	... ...	19,482,000	... ...
				22,762,800	
Deduct heat absorbed as shown in Table				10,862,030	
Available heating power of the Gases.					11,900,770
Loss in heat value of One Ton of Coal by Gasification . . .					3,679,230
Equal to 23·5%.					

TABLE IX.

Showing the Product of One Ton of Coal when 50 per cent. of its Carbon is Incinerated with Excess of Steam.

COMPOSITION OF COAL.			STEAM USED.	CHEMICAL REACTIONS.	PRODUCTS.		VOL. OF GASES AT 500° C.		VOL. OF GASES AT 16° C.	
	Per Cent.	Pounds.	Pounds.			Pounds.	Cubic Feet.	Per Cent.	Cubic Feet.	Per Cent.
Carbon,	78·53	1758	2197·5	$3C + 5H_2O$	Carbonic Oxide,	683·6	26,177	6·15	9,250	10·06
(To Incinerate 879),	—	—	2500	$= CO + 2CO_2 + 5H_2$	Carbonic Acid,	2148·7	52,355	12·30	18,500	20·13
Hydrogen,	5·64	126	—	—	Hydrogen,	338·6	181,584	42·69	64,164	69·81
—	—	—	—	—	Nitrogen,	8	374	0·09	—	—
Nitrogen,	1·00	22	—	—	Ammonia,	17	1,075	0·25	—	—
Sulphur,	1·11	25	—	—	Sulphuretted Hydrogen.	26·6	826	0·19	—	—
Oxygen,	9·69	217	—	—	Water, {	244 2500	163,075	38·33	—	—
Ash,	4·03	92	—	—	Ash,	92	—	—	—	—
					Carbon,	879	—	—	—	—
	100·00	2240 +	4697·5	= 6937·5		6937·5	254,466	100·00	91,914	100·00

Table X.

Showing the Heat Units Absorbed in the Partial Incineration of Coal with Excess of Steam.

To heat 2240 lbs. of Coal to 500°C	2240 × ·24 × 500	268,800
To raise 4697 lbs. of water into Steam at 100°C	4697·5 × 620	2,912,470*
To heat 4697 lbs. of steam from 100° C to 500°C	4697·5 × ·47 × 400	883,130*
Heat absorbed in the reaction $3C + 5H_2O = CO + 3CO_2 + 5H_2$	879 × 1875	1,648,125
To maintain the temperature of the apparatus against losses by convection, radiation, &c.—equal say to 5% of Coal incinerated, or	112lbs. Carbon × 8080	904,960
Total heat units		6,617,485

* By suitable regenerative condensers a large proportion of this heat may be recovered.

TABLE XI.

Showing the Comparative Heating Value of One Ton of the Original Coal, and of the Gases produced by the Incineration of 50 per cent. of its Carbon with Excess of Steam, Deducting from the latter the Heat Absorbed in their Production.

POUNDS.		HEAT UNITS PER LB.		HEAT UNITS.	HEAT UNITS.
2240	Coal, ...	7000			15,680,000
638·6	Carbonic Oxide,	2400		1,640,640	
383·6	Hydrogen, . .	34,000		11,512,400	
879	Carbon, . . .	8080		7,102,320	
				20,255,360	
			Deduct heat absorbed as shown in Table, ...	6,617,485	
			Available heating power of the Gases, ...		13,637,875
			Loss in heat value of 1 Ton of Coal by gasification, ... Equal to 13 per cent.		2,042,125

TABLE XII.

FIRST PROCESS.

Distillation at a Low Red Heat. (In common use prior to 1881.)

No. 1 SHALE.

	Nitrogen per cent.	Pounds Nitrogen as NH_3, or with C + H.		Total lbs. Nitrogen.
2240 lbs. of Shale	0·72	...	16·14	16·14
Produces—				
290 lbs. Crude Paraffin Oil . . .	1·16	...	3·36	...
150 „ Watery Distillate . . .	1·80	2·70	...	...
120 „ Gas	...	...	...	...
1680 „ Residue { 168 lbs. Carbon, 1512 „ Ash }	0·60	1·20	8·88	...
	...	3·90	12·24	16·14

No. 2 SHALE.

	Nitrogen per cent.	Pounds Nitrogen as NH_3, or with C + H.		Total lbs. Nitrogen.
2240 lbs. of Shale	0·87	...	19·5	19·5
Produces—				
378 lbs. Crude Paraffin Oil . . .	1·45	...	5·45	...
150 „ Watery Distillate. . . .	0·70	1·05	...	...
150 „ Gas	...	...	...	...
1562 „ Residue { 531 lbs. Carbon, 1031 „ Ash }	0·83	1·20	11·80	...
	...	2·25	17·25	19·5

TABLE XIII.

SECOND PROCESS.

Distillation at a Low Red Heat with Current of Steam. (In common use prior to 1881.)

No. 1 SHALE.

	Nitrogen per cent.	Pounds Nitrogen as N. H_3, or with C + H.		Total lbs. Nitrogen.
2240 lbs. of Shale	0·72	...	16·14	16·14
Produces—				
290 lbs. Crude Oil	1·16	...	3·36	...
150 „ Watery Distillate . . .	2·60	3·90	...	...
120 „ Gas	...	...	...	...
1680 „ Residue { 168 lbs. Carbon, 1512 „ Ash }	0·53	...	8·88	...
	...	3·90	12·24	16·14

No. 2 SHALE.

	Nitrogen per cent.	Pounds Nitrogen as N. H_3, or with C + H.		Total lbs. Nitrogen.
2240 lbs. of Shale	0·87	...	19·5	19·5
Produces—				
378 lbs. Crude Oil	1·45	...	5·45	...
150 „ Watery Distillate. . . .	1·90	2·25	...	...
150 „ Gas	...	...	...	...
1562 „ Residue { 531 lbs. Carbon, 1031 „ Ash }	0·75	...	11·80	...
	...	2·25	17·25	19·5

TABLE XIV.

THIRD PROCESS.

Distillation at a Low Red Heat with Current of Steam, the Residue being subsequently Treated with Excess of Steam at a Bright Red Heat.

(YOUNG & BEILBY'S PROCESS.)

No. 1 SHALE.

	Nitrogen per cent.	Pounds Nitrogen as NH_3 or with C + H.		Total lbs. Nitrogen.
	0·72		16·14	16·14
2240 lbs. of Shale produces :—				
290 lbs. Crude Oil, ...	1·16	...	3·36	...
150 „ Watery Distillate, . . .	8·00	12·00	...	...
244 „ Gas, ...	...	...	...	...
1546 „ Residue { 34 lbs. Carbon,	...	...	...	...
1512 „ Ash,	0·05	...	0·78	...
		12·00	4·14	16·14

No. 2 SHALE.

	Nitrogen per cent.	Pounds Nitrogen as NH_3 or with C + H.		Total lbs. Hydrogen.
	0·87		19·5	19·5
2240 lbs. of Shale produces :—				
478 lbs. Crude Oil, ...	1·45	...	5·45	...
150 „ Watery Distillate, . . .	8·33	12·50	...	...
411 „ Gas, ...	...	...	...	...
1151 „ Residue { 120 lbs. Carbon,	...	...	...	...
1031 „ Ash,	0·13	...	1·55	...
		12·50	7·00	19·5

ABSTRACT.

Showing the Available Heat Value of Gases made by the methods shown in Tables.

		Available Heat.
Coke burned completely in air, ...		100·0
Coke gasified by limited oxidation with air,	Tables I., II., ...	69·3
Coke gasified by limited oxidation with steam,	,, III., IV., V.,	79·6
Coal, complete incineration of its Carbon with excess of steam,	,, VI., VII., VIII.,	76·5
Coal, incineration of 50% of its Carbon with excess of steam,	,, IX., X., XI.,	87·0

DISCUSSION OF MR GEORGE BEILBY'S PAPER ON YOUNG & BEILBY'S PROCESS FOR THE TREATMENT OF COAL.

The PRESIDENT said Mr Beilby had favoured them with a highly instructive paper, the value of which they would not be able fully to appreciate until they saw it in print. In the meantime Mr Beilby would be very glad to offer any explanations that any member might desire.

Mr DIXON said Mr Beilby had used the word "Incineration" very often; he (Mr Dixon) would like to get an explanation of what he meant by it. In reading the paper they might be groping in the dark through not knowing that.

Mr BEILBY said he had used the word because it had been used by his German friend, Dr Grouven, and having introduced a new process it seemed to him an advantage to use an expression special to itself. He might, of course have used the word "burning" equally well. He had tried as far as possible to clear the subject of any mystery and to make quite clear what had been done, what was claimed, and what they believed to be novel.

The PRESIDENT said Mr Beilby had certainly made the subject very clear—at least to those of them who had known previously about chemical manufactures; and he had no doubt they would all find, when they saw it in print, that it was as plain as the subject possibly could be made.

Mr ROWAN asked if any special means were taken to prevent the escape of the hydro-carbon gases in the upper portion of the retort by the feeding hopper. It seemed to him that considerable pressure would be caused at that point by the gases given off in the distillation of the coal; the exit pipe being nearly half-way down the retort. He thought, if he might be allowed to suggest this, that it would add to the completeness of the information which Mr Beilby had given them, especially as this was an entirely new method of treating coal, if they had an idea of what was the smallest extent to which the process could be profitably applied, and something like the cost of applying it, say per ton of coal treated.

Mr BEILBY said, as to the first point raised, viz., the possible

escape of gas by the hopper; this was obviated by never allowing the bottom of the hopper and the feeding tube to be quite empty: the small coal or dross would ordinarily stop the passage of gas; but, as a further precaution, the steam, which had at any rate to be introduced at the top of the retort, was used to prevent the outward passage of gas. The free passage of gases through the material in the retort was insured by the system of continuous slow feeding, whereby the coal was coked quickly and in thin layers; so that with little attention the whole mass could be kept pervious to steam or gases. This was a novel and important feature in the new system. As to the second point raised by Mr Rowan, viz., the profitable application of the process: this must depend very much on circumstances special to each case. The Oakbank Oil Coy. had begun by erecting plant to treat 8 to 10 tons of dross per day; and were now proceeding with the plans for the alteration of their whole work under the new system. The plant already erected had cost £700, or say £80 per ton of coal per day; but a considerable saving was to be expected in the erection of additional benches. Plant to work only 10 tons a day would necessarily be much more heavily saddled with "oncost" charges than plant to work 100 tons.

Mr RONALDSON asked what the dimensions of the retort were.

Mr BEILBY explained that the retort was 17 feet from the bottom of the fireclay to the top. The bench was 10 feet wide exactly. The retort, which was shown in cross section, was at the bottom 2 feet 3 inches. It was the same breadth the whole way up and only tapered on two sides. Its dimensions at the top were 2 feet 3 inches by 9 inches.

The PRESIDENT called for a vote of thanks to Mr Beilby for his paper, which was given. The meeting then adjourned.

NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES.

THE MINERAL RESOURCES OF NEW ZEALAND,

BEING an abstract of papers read before the Liverpool Geological Association, by Henry Bramall, C.E., contains some valuable information in a condensed form of the Physical, Geological and Mineralogical aspects of the country. A description is given in detail of the fields in which the various minerals are found; and the size, thickness, and values of several lodes and seams at present or formerly wrought. Ores of all the useful metals have been found as well as silver and gold, but none seem to have been wrought to any extent except the latter, the exported value of which from 1857 to 1882 was over £38,600,000 stg. Coal, lime, and the various ores of iron are found very widely distributed over nearly all parts of the country, either in conjunction with coal or at no great distance from it. No attempt to manufacture iron, except experimentally, has yet been made; and the only use to which some of the Hematites are at present being put is the manufacture of red oxide paint.

No true Palœozoic Coal has yet been found in the colony. All the seams at present known belong to the Cretaceo-tertiary, and of the kind known as Brown Coal with varieties ranging from Lignite to coal which cannot be distinguished from true Anthracite. These varieties occur through purely local causes, such as the proximity of volcanic flows, &c. The coal basins are of limited vertical depth, and generally contain only one good workable seam (but which may be 55ft. thick, usually 5ft. to 7ft.) From the 104 collieries at work in 1881 the output was 337,000 tons. The large proportion of water (as high as 20%) in some seams will be found rather a serious drawback to their use for steam and manufacturing purposes. Petroleum, yielding oil like the Canadian variety, is found in several places. Good building stones are found all over the country; also brick, tile, fire and china clays; glass, sand, sulphur, chalk, cement, steatite, talc, asbestos, kieselguhr, &c., &c. To any one interested in the colony, the papers are well worth perusal. G. A. B.

TRANSACTIONS OF THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS, VOLUME VIII., PART LXVIII.

The FLEUSS DIVING and NOXIOUS GAS APPARATUS.—In the discussion upon the merits and advantages of this apparatus, views were expressed as to the necessity for having such an appliance at each colliery. Some members, while concurring with this view, thought it would be advisable, in the first place, to form central stations to serve for each district. In consideration, however, of the fact that the members of the Institute, as a body, had no practical knowledge of the efficiency of the invention, it

was agreed, before recommending its adoption, that a committee, appointed for the purpose, should procure two of the apparatus from Mr Fleuss, and have them thoroughly tested.

Discussion on the preliminary REPORT of the ROYAL COMMISSION on ACCIDENTS in MINES.—GOB FIRES.—The President mentioned that in the main seam of the Leicestershire coal-field many gob fires, due to spontaneous combustion, had been avoided by driving out headings to the boundary and working back, thus leaving the gob behind; the small coal at the same time being sent out of the pit as much as possible. It was the general opinion that many gob fires were caused by water acting upon iron pyrites; but, these fires having occurred where it was quite dry, it was supposed by some members that the grinding pressure on the goaf might generate sufficient heat to cause combustion.

An Abstract of a German paper upon the "ADMIXTURE of LESS VALUABLE INGREDIENTS with PORTLAND CEMENT" is given. Experiments were made to ascertain the effects of the introduction of various ingredients to adulterate cement; and the result was that it was found that good Portland cement is not improved by the admixture of foreign materials. J. M. R.

REPORTS of the INSPECTORS OF MINES of the ANTHRACITE COAL Regions of PENNSYLVANIA for the Year 1882.

No volume in the Library of our Mining Institute will be perused with more interest by, or be of more value to our Mining Managers than this one, giving as it does an account of how every accident occurred, and how, in most cases, they might have been prevented.

Valuable statistics are given of the rapid progress that is being made in Coal mining in the above regions, both in the quantity put out and the great improvements that are taking place in the ventilation and working of the mines. Many plans and diagrams are given shewing how ACCIDENTS occurred, and a glance at them will shew how many valuable lives have been lost which a moment's thought, or strict discipline would have prevented. From the same plans a clear idea is given of the method adopted in WORKING the THICK and HIGHLY INCLINED SEAMS.

In the report of the Inspector of the Luzerne and Carbon Counties (Middle District) a table is given shewing from experiments the great advantage of large intakes and outlets, and of splitting the air currents. In this report some valuable information is given on FIRES in MINES, and the methods adopted for extinguishing them. A plan or diagram is given of the apparatus used by Goldsworthy Gurney, Esq., in extinguishing a fire in Astley Colliery, near Manchester, in 1849, by forcing choke damp (through a very simple contrivance) into the workings.

Plans are given of DAMS which were built in the openings round a shaft to resist the pressure of water with a head of eighty feet, which filled some old workings, the shaft being afterwards sunk to a lower seam, which is now being worked out.

W. C.

THE MANCHESTER STEAM USERS' ASSOCIATION.

Chief Engineer's Monthly Report, Jan. to June, 1883.

The objects of this Association are the prevention of boiler explosions and of any

action on the part of legislators of a nature harassing to steam users. That the former of these objects is attained to a satisfactory extent and that the latter is, in part at least, attained, a perusal of this report leaves little dobut.

To all interested in the use of steam the contents of this pamphlet offers many valuable hints; and, on looking into the series of facts connected with boiler explosions arrayed in its pages, one may very well ask, would it not be well to have similar associations in all parts of the country?

An abstract of the report shows that out of the 6431 boilers inspected by the Association 6% were defective, and that 3·3% of these latter were dangerously so; and it is to be noted that out of the 13 dangerous boilers 7 were unsafe from defective safety valves.

A copy is given of Mr Broadhurst's Bill, brought in for the purpose of preventing any one being employed to fire a boiler on land who has not passed a Board of Trade examination and received a certificate. The Bill was read a first time on 19th February last. The M.S.U.A., in criticising the Bill, approves of intending Boiler-minders being put through a strict examination, not, however, by a B. of T. official but by their employers who should be held responsible to the public. It objects to the Bill for various reasons —1, The Bill lays the blame on the wrong person. The annual reports of the M.S.U.A. have uniformly shown that the cause of nearly every explosion is the weakness of the boiler: which points the moral:—examine the boiler, rather than the stoker. 2, The Bill would be harassing to steam users by limiting their choice of men. To realise one of the many inconveniences which must spring from this it is only necessary to imagine a strike among the firemen. 3, The Bill is vague in its want of definitions regarding the persons employed and their examination.

Of the 18 explosions which occurred during the six months throughout the kingdom, 4 were at collieries. Five arose from boilers insured with Joint Stock Insurance Companies; a fact which shows that immunity from danger is not insured from boiler-insurance, though from pecuniary loss it may be. A point of detail much insisted on is that all the joints of boiler fittings should be made metal to metal, and not with india-rubber rings.

For steam users troubled with incrustation through carbonate and sulphate of lime in the feed water, some remarks about the use of the Porter-Clark process as an antidote against the former, and of hydrated magnesia against the latter, may prove of interest.

J. H. R.

The JOURNAL of the IRON AND STEEL INSTITUTE, No. 1, 1883.

"The PRODUCTION and UTILISATION of GASEOUS FUEL in the IRON MANUFACTURE," by W. S. Sutherland. Mr S. observed the advantage to be gained in strength and economy by welding instead of rivetting the seams of boilers; but, finding the ordinary smiths' hearth unsuitable for the heating, he came to use gas fuel; and was the first to introduce into England STRONG'S WATER-GAS PRODUCER, the working of which is described as follows:—"Part "of the fuel is burned as completely as possible to carbonic acid and water; but "the resulting heat is stored up, partly in the remainder of the fuel and partly in "regenerators; that in the regenerators being made to heat up, to a sufficiently high "degree, a quantity of steam. This superheated steam is passed through the hot "fuel, and forms with it carbonic oxide and hydrogen, which go away to be stored up "and used."

Results shew that from one ton of Staffordshire coal 55,000 cubic feet of gas are produced, or about 25 cubic feet per lb. of carbon. The heating power of the gas seems

about one half of coal gas; but it may be produced for 3d per 1000 feet, after paying for coal, labour and plant. The profit derived from the residual products is stated to be 2s to 3s per ton of coal. Interesting particulars are given as to the working out of the system, which has been established at several works in Birmingham. In the discussion on the paper it is stated that a certain firm, which formerly paid £300 a year to the Birmingham Corporation for gas, has, by using this gas, reduced the cost to £100 a year.

"COAL WASHING MACHINERY, employed by the Bochum Mining and Smelting Coy.," by Fritz Baare, Westphalia. A description, illustrated with drawings, is given of machinery turning out 1000 tons a day. Details of the washing plant are as follows .—

"1. The Briart patent screens, by means of which the large coal is separated from the "small, the latter only being treated in the washers.

"2. The separating drum, which divides the coal to be washed into different sizes.

"3. The washers for the coarse or nut coal.

"4. The washers for the fine coal.

"5. The disintegrator for washed nuts.

"6. The arrangements for transporting the washed coal to the store bunker.

"7. The settling ponds.

"8. A centrifugal pump, effecting the circulation of the necessary water for the "washing process, and actuated by a steam engine of about 140 h.-p."

The boxes or troughs in which the coal is washed have a perforated bottom, covered by a bed of coarse pieces of slate or felspar having a specific gravity of from 2 to 3. A rocking motion is imparted to the water in the washers by the up-and-down strokes of pistons, water regulated by a valve entering the box under the piston. The motion of the water separates the particles of shale and other heavy matter from the coal, and at each down stroke of the piston the bed of slate or felspar is sufficiently raised and opened to allow the particles of shale to pass through it, and through the perforated bottom into the lower part of the trough. The coal, which sinks more slowly, does not fall on the bed of slate till it is firmly closed, and it is carried away by the current of water above.

A Paper by M. Albert Riche, on IMPROVEMENTS in RAILWAY and TRAMWAY PLANT, will repay perusal.

J. B.

Volume third of the TRANSACTIONS of the AMERICAN SOCIETY of MECHANICAL ENGINEERS contains the proceedings of the Philadelphia Meeting in April, 1882. At the opening, a Memorial Session was held in honour of their late Vice-President, Alexander Lyman Holley, the great American engineer, and some well-merited tributes were paid to his memory. The following papers were then read :—

"The DETERMINATION of HEATING SURFACE required in VENTILATING FLUES," by Professor Trowbridge, Columbia College, N. York.

"A STANDARD GAUGE SYSTEM," by George M. Bond, Hartford, Conn.

"THERMO-DYNAMICS of Certain Forms of the WORTHINGTON and other COMPOUND PUMPING ENGINES," by Professor S. W. Robinson, Ohio University.

"On the SPECIFIC HEAT of PLATINUM," by J. C. Hoadley, Boston.

"CHRONOGRAPH for ENGINEERING PURPOSES," by W. R. Eckart, C.E., San Francisco.

"AVERAGING MACHINES," by W. S. Auchencloss, Philadelphia.

"EXPANSION of STEAM and WATER without TRANSFER of HEAT," by A. Faber du Faur, New York.

"Description of the EDISON STEAM DYNAMO," by T. A. Edison, P.H.D., New York City; and Charles T. Porter, Philadelphia.

"On a THEOREM of RANKINE relating to the ECONOMY of SINGLE ACTING EXPANSION ENGINES," by William P. Trowbridge, Prof. Eng. Columb. Coll., New York.

"On the SEVERAL EFFICIENCIES of the STEAM ENGINE, and on the CONDITIONS of MAXIMUM ECONOMY," by Robert H. Thurston.

"Note on the ECONOMY of the WIND MILL as a Prime Mover," by Alfred R. Wolff, M.E., New York City.

These papers deal very elaborately with the subjects on which they are written, and some of them are well illustrated; but they are all of a very technical nature, and, on that account, not so interesting to the general reader as they should be to the specialist.

In an address delivered to the American Society of Mechanical Engineers at their meeting in Philadelphia, last year, Professor Egleston gave an account of the work done by the "COMMISSION on TESTS of IRON, STEEL, and CONSTRUCTIVE MATERIALS," which was appointed by the U.S. Government in 1875. This Commission (of which the Professor was chairman) built, on an entirely new principle, a testing machine of remarkable power and accuracy, which was erected at Watertown Arsenal; and the results of tests made by it have been such as to revolutionize most of the accepted ideas upon the methods of testing the metals. This machine is by law allowed to be used by private parties; and it is largely taken advantage of by engineers of companies who wish to test their material before using it—they paying the working expenses, which amount to about $25 per day.

One important result of some tests made with this machine shows that the habit of testing iron or steel on diminished areas, and calculating that the larger section is stronger in direct proportion to the increase of area, is faulty, and does not give true results. The Professor further points out that the factors of safety hitherto used by engineers are taken from tables constructed many years ago by foreign engineers, on materials made under entirely different processes from those now in use; and that tables and formulæ are being used, which are only approximately reliable; and he strongly advocates the compilation of an entirely new set of formulæ, based in every case on careful tests made with full sizes.

In the course of his address, Professor Egleston makes occasional references to what he terms the law of "FATIGUE and REFRESHMENT of METALS." This law will probably be new to most people. According to the Professor, metals in use under certain conditions become "fatigued," and on these conditions being reversed, and a period of repose allowed, they become "refreshed." He quotes some very curious incidents in support of this theory. This Commission has spent all the money voted for it, and its term of office has expired; but it is to be hoped that in the interests of science, the United States Government may see its way to re-appoint it. J. P.

The vol. for 1882 of the Transactions of the American SOCIETY of CIVIL ENGINEERS contains a paper by Wm. P. Shinn, on the INCREASED EFFICIENCY of RAILWAYS for the TRANSPORTATION of FREIGHT.

By way of introduction, the author gives some very valuable statistical tables of the great growth and producing power of the United States of America in the ten years,

from 1870 to 1880, which called for greater facilities and forced on the development and efficiency of the railway system of that country. The paper is divided into two heads, viz., 1st, The improvements in the physical condition of the railroads, and, 2nd, improvements in the administration. The construction of a good permanent way is the necessary foundation of all successful and economical railroad management. The introduction of steel rails within the last ten years has enabled railway companies to put on much heavier engines and cars, to run at an increased speed. The cars are now being constructed to carry twenty to thirty tons. What was stated under the second head—the improvements in the administration—gave rise to more discussion. Mr Shinn, in summing up the discussion, contributes another valuable paper in the June number of this year. He enters very minutely into the working of the plant of the American lines, and gives very valuable tables showing the terminal charges on the principal railways in this country, as well as the usages of plant on the continental railways. Throughout the paper it is shown that there seems to be a felt want in the method—something like the working of the clearing house in this country—of charging for the use of cars on a foreign line. The writer strongly advocates a per-diem charge for cars running on a foreign line instead of a mileage rate, as is generally adopted here and in continental countries. One very singular feature in the administration is the very great falling off in the average work done by the cars on some of the railroads, showing that as the number of cars has increased, the daily average miles run by each car has steadily decreased. For instance, for the four years ending 1879 the average daily running of cars on the Union line was 79·91 miles; and for three years ending 1882 the average was only 53·74 miles. The running over other lines is shown to have decreased in the same ratio. It is, however, difficult for us to draw comparisons, as even with the smallest mileage rate it seems very great compared with the work per waggon in this country. In our best managed railways one trip per week is considered very good work, and bears very favourable comparison with the Prussian, Austrian, and French railway systems, which show little more than an average of twenty trips per year for each truck.

J. S.

"The POROSITY and SPECIFIC GRAVITY of COKE," by F. P. Dewey. Transactions of the American INSTITUTE of MINING ENGINEERS—June, 1883.

There is great need of careful and systematic examination of coal and its products; because there is not only much ignorance about the constitution of coal itself prevailing, but there are also many phenomena connected with the products which require investigation.

Little is known about the density of carbon as it exists in coal; and less, if possible, about how the elementary bodies are combined; or what is their state of condensation in coal. As for Coke, chemical analysis has as yet thrown no light on the causes of the different physical properties possessed by varieties of Coke having the same ultimate chemical constitution.

In the light of such facts, a painstaking examination, such as the above paper records, of some of the physical features of Coke must be hailed with satisfaction.

The paper bears evidence of conscientious work, and the results, which are given concisely in a table at the end of the paper, are therefore valuable, although not considered by the author complete enough to form the basis of any general conclusions.

The method of ascertaining "the true specific gravity; the apparent specific gravity or relationship between the entire volume of the coke and an equal volume of water; and

the percentage of cells in the coke and volume of cells in a given weight," is very ingenious. It is a modification of the plan of weighing specimens first in air and then in water and in air, proposed by Dr. T. Sterry Hunt in his Chemical and Geological Essays. The author of this paper lays stress upon the porosity of coke as being that which determines its rapid combustion by penetration of the gases into its substance; and yet it is admitted that the cell walls may be too thin to impart to the coke a sufficient degree of resistance to crushing. Hence the necessity for estimating the relation between the volume of the cells and the weight of the coke.

Some interesting remarks on the physical qualities of different kinds of coke and their behaviour in the blast furnace are to be found in a paper on "Blast Furnace Materials," by J. Lowthian Bell, in "Proceedings of the Institution of Mechanical Engineers," vol. for 1871; and there are papers scattered through the volumes of the Iron and Steel Institute proceedings. F. J. R.

THE MINING INSTITUTE OF SCOTLAND,

8th NOVEMBER, 1883.

Through the kindness of the Engineers and Contractors for the GLASGOW CITY and DISTRICT RAILWAY, the members of the Institute had an opportunity of visiting the works in progress in connection with that railway on the afternoon of 8th November, 1883.

Tunnelling was being carried on from shafts at various points on the route, extending from High Street to Dumbarton Road, and the members were admitted in parties to the tunnels at these shafts.

The excavations were chiefly in boulder clay and freestone, and were very accurately made, so that no space should be left between the brick arching when finished, and the solid.

The system of timbering, for the purpose of keeping the roof and sides secure until lined with the arching, was examined with special interest by the members, of whom there was a large turn-out.

The Secretary communicated to the engineers, Messrs Simpson and Wilson, the thanks of the Council and members for the privilege they had enjoyed, acknowledging also the kindness of the Contractors.

The members of Council afterwards examined in the Offices of the Tharsis Sulphur and Copper Company, 136 West George Street, some pieces of mine timbering that had been found in old workings of the company's mines in Spain. The wood,

which was pine, was in an excellent state of preservation, due to its having been impregnated with sulphate of copper in the mines. Judging from the dates of certain coins found in the mines, and from other circumstances, it is believed that the mines were worked, and the timbering put therein, about two thousand years ago. What appeared to be the framework of the bottom of a shaft was only about two feet square, inside measurement, and the wood securing the working roads admitted of an opening two feet five inches in height, by one foot eight inches in width.

GENERAL MEETING, 8th NOVEMBER, 1883,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW.

RALPH MOORE, Esq., Ex-President, in the Chair.

Upwards of seventy members were present.

The minutes of the last General Meeting were read by the Secretary and confirmed.

The following gentlemen, who had been duly nominated at a former meeting of Council, were elected by ballot, and admitted as Ordinary Members :—

JAMES PENMAN, Blairmuckhill Colliery, Harthill.

JAMES PARK, Stonelaw Colliery, Rutherglen.

DAVID LANDALE, Edinburgh.

R. D. MUNRO, 162 Buchanan Street, Glasgow.

JOHN REID, 74 Bath Street, Glasgow.

GEORGE W. SMITH, Port Elizabeth, South Africa.

DISCUSSION OF MR BEITH'S PAPER AND THE COMMITTEE'S REPORT ON EXPERIMENTS WITH FORCING AND EXHAUSTING FANS.

The Secretary read the following communication from

D. A. W. ROBERTSON—As the number of forcing Fans at work in this country must be few indeed, little opportunity is offered for forming reliable data on this subject, and as perhaps there has seldom been an opportunity given to those interested to test the performance of the same fan under precisely similar conditions, both forcing and exhausting, the following notes from memory of such a trial I venture to believe may be of interest to the members of the Institute. A few years ago I erected a Schiele Fan, 5ft. 6in. dia., driven by a single horizontal engine, 14in. dia. × 2ft. 4in. stroke, working expansively, and steam cut off at $\frac{2}{3}$ths, the power being transmitted by strap to pulley of fan shaft, the steam pressure 45lbs., the average revolutions of engine 110, and geared in the ratio of 5.3 to 1; the number of revolutions of fan was thus 583. At this speed the ventilation was 60,000 to 65,000 cubic feet at a water gauge of 3″. The upcast pit owing to a heavy fall of water was naturally a downcast, and the downcast having a column of steam pipes in it was naturally an upcast. This was clearly indicated whenever the fan was stopped, the air reversing instantly and a strong current of perhaps 10,000 or 15,000 feet passing in the contrary direction. Owing to this circumstance, and having an idea that fans would give a better duty forcing than exhausting, I determined to make a trial of this fan forcing. This was a very simple matter, involving only the construction of a large box from the exhaust of fan to the top of what was formerly the upcast. The result was not as satisfactory as might have been expected; the quantity of air was certainly as great, the water gauge being about the same, but no advantage seemed to be gained from the natural ventilation in favour of the fan. As this was, I consider, a fair trial, the impression left on my mind was that (to quote the words of Mr Moore) it is six and half a dozen whether a fan exhausts or forces. I may state that this fan when first started gave with the same revolutions only

about 23,000 feet, with a water gauge of 1¾", very much to my disgust. Being young and having Guibal tendencies, I immediately jumped to the conclusion that the Schiele fan was at fault; and if times had been good, the probability is that it would have been removed. But times were bad, and I had therefore to make the best of it, with the result that by rearranging the whole system of ventilation, and enlarging the main airways, the ventilation gradually went up to 60,000 feet, with the same fan and with the same speed. I did not fully understand till then of how much greater importance it is to have good airways, and a good system of ventilation, than even good fans. In my humble opinion, the difference between a Guibal, Schiele, or Waddle fan of equal capacity, either forcing or exhausting, each working under favourable conditions as regards airways, is not appreciable. It is interesting to note that a Schiele fan of this size with this ventilation produces a quantity of air equal to at least four times its own capacity, whereas Guibal fans do not on an average produce above half their capacity.

The Secretary read also a communication from

Mr JAMES BALLANTYNE, in which an opinion in favour of the forcing fan was expressed.

Mr BEITH said—Mr J. H. Ronaldson in opening the discussion at last meeting on the forcing and exhausting fans, after calculating the Theoretical Water-Gauge and Manometric efficiency, says :—

"From the calculations it seems probable that natural ventilation was assisting the forcing fan to some extent, and the exhausting fan also, but to a smaller degree, as the manometric efficiency drops from the low speeds to the high."

I have gone over the calculations for the theoretical water-gauge and manometric efficiency, and find the figures, correct. I must, however, refer to the report of the committee who have made further experiments which are in corroboration of the facts set forth in my paper. I would certainly like to obtain further and better data than those which are before us before changing my opinion as to the relative value of the fans. During the time the experiments were made, the thermometer on the surface registered 60 degrees, while the temperature of the mine was 56 degrees,

which shows that no assistance could be got by natural ventilation, owing to the temperature on the surface, being only 4 degrees in excess of that in the mine. In reply to Mr Hastie, I have to remark that the different results obtained now and in 1879 in the exhausting fan are so apparent that it is scarcely necessary to detail them. It is clear that as the workings are more and more developed, causing greater resistance, the quantity of air discharged at a given speed must become less. This is a law which applies to every fan. The doubt which exists in Mr Hastie's mind as to the figures will be dispelled by comparison with those obtained by the committee. Mr Smart, in contributing to the discussion, has very clearly given his opinion. Although great diversity of opinion exists in respect to the laws which govern or affect ventilation, I must say here that I thoroughly agree with Mr Smart; because if we make the propelling power at the downcast as much as possible above that at the upcast, it is the only way to produce a large quantity of air. Regarding the respective upkeep of the two fans, in my opinion the fresh air flowing in on the forcing fan does not to the same extent deteriorate the cast-iron as in the exhausting fan. At the upcast shaft all the vapours from the mine flow into the exhausting fan, and tend to act more destructively on the exhausting fan. I am sorry that Mr Drinnan does not agree with me, but I cannot see anything in his remarks which would lead me, if again treating on this subject, to express my views differently. I am certain that so far as the construction and fitting of the fans go, to produce the maximum quantity of air, they are not defective.

Mr RONALDSON would like to ask if the Committee had made any allowance for the friction of the anemometer, as he had found that the allowance varied for different speeds.

Mr ROBSON said there was no allowance made for friction. It was considered by the Committee that, at such a high velocity as the air was travelling at, any little difference in the friction between one velocity and another would not be appreciable, and they took the actual velocity as indicated without any allowance in any case.

Mr DRINNAN agreed with Mr Robertson that natural ventilation had a good deal to do with the increase that was obtained

in the use of the forcing fan. As he understood the description which the Committee had given, they removed the cover of the down-cast so as to allow it to exhaust into the open air. He questioned if it would exhaust into the open air. He was rather inclined to believe it would be going down the pit and through the mine, and in that way they would be getting the benefit of natural ventilation. With respect to the upcast, he maintained the assistance of that natural ventilation was not obtained, and in order to have made a true test, the downcast should have been scaffolded over so as to prevent the air getting down the mine and cause it to go into the open air.

Mr BEITH, in reference to what Mr Drinnan had just stated, said if they scaffolded the downcast below the fan tunnel they would require to do the same with the exhausting fan to ascertain the difference between the two.

The CHAIRMAN—If I understand Mr Drinnan, he says the Committee have added the natural ventilation to the result given by the forcing fan.

Mr BEITH—Would the natural ventilation not assist the exhausting fan as well as the forcing fan?

Mr ROBSON—It is only right to say that in neither case was there any effort made to prevent natural ventilation affecting the question,—that is to say, if there was any air drawn from the mine in the case of the exhausting fan of course it mixed with the air taken in from the surface. In the case of the forcing fan, any air which inclined to go down the shaft and through the workings would naturally do so. More expense would have been incurred in scaffolding the pits. I think there was more air drawn through the exhausting fan from the pit than there was propelled through the pit by the forcing fan.

Mr R. T. MOORE said he did not think the natural ventilation would have much effect on the experiments. The natural ventilation in the Clyde Coal Co.'s pits would not be more than 10,000 cubic feet per minute. In Mr Beith's experiments with the exhausting fan ·45 of an inch water gauge gave 52,000 cubic feet per minute. The water gauge then necessary to drive 10,000 cubic feet through the workings, was $\left(\frac{10,000}{52,000}\right)^2 \cdot 45 = \cdot 018$ of an inch.

If the fan gave ·45 inch water gauge, the water gauge produced when assisted by the natural ventilation would be ·45 + ·018 = ·468 of an inch, and the quantity of air would be $\sqrt{\frac{468}{45}}$ = 1·02 times greater than if there was no natural ventilation. So that even if the fan had been drawing the whole of the air from the mine, the natural ventilation could only have affected the quantity of air to the extent of 2 per cent., and, supposing the natural ventilation to have double the effect on the forcing fan that it had on the exhausting one, it could only affect the question to the extent of 1 per cent.

In the experiments, however, by far the greater part of the air was drawn from the surface, so that the effect must have been very small indeed.

The experiments, they were sorry to say, did not lead them to any very satisfactory results; indeed, they were very puzzling, as in the air-way with the larger cross sectional area it took a larger water gauge to draw a smaller quantity of air.

In the air entering the exhausting fan, there was some steam from a small donkey engine, and the walls of the tunnel were damp and clammy, while in the forcing fan the air was dry, and everything was clean: possibly this might affect the co-efficient of friction to such an extent as to account for the difference. It showed, however, how very difficult it was to put two fans on different mines under precisely the same conditions, and led the committee to recommend that the same fan should be tried on a mine, first as a forcing fan and then as an exhausting one. They said on a mine, because then the friction would be so great that the difference due to the connections of the fan to the pit, when forcing and exhausting, would be inappreciable.

Really, it was not a question of fans at all. The fan remained the same in both cases, and the only difference was in whether the air-ways were attached to the ear or to the chimney. The question was rather—Whether a positive or a negative water gauge would send the larger quantity of air through the workings. Ventilation was produced by the difference of pressure on the upcast and downcast shafts. With a barometric pressure of 30 inches there were 400 inches water gauge on both downcast and

upcast, so that if a negative inch of water gauge was produced, the pressure on the upcast was 399 inches, and that on the downcast 400 inches; if a forcing fan were used there would be 401 inches on the downcast, and 400 on the upcast. When looked at in this light it did not seem so striking as when they said there was an inch of water gauge, positive or negative. He did not think there should be any difference in the amount of ventilation produced by a positive or a negative inch of water gauge.

Mr HILL said he was not aware of these experiments till that night. With experiments on the two different fans at different places he could not see the value of the results; but he should like very much to see the fans used at the same place and in doing exactly the same work. If this were done they would come to some useful conclusion. Otherwise, they might as well try two different engines in two different boats.

Mr STEWART said he would like if any member could state if there was any theoretical reason why the one fan should do more work than the other. He could not see any reason. They wanted a certain quantity of air passed. It seemed to him more a question of which kind of machine or machinery they could get; but theoretically the same power and expense ought to be incurred with the one as the other if there were a proper adaptation of the machinery to the purpose.

The CHAIRMAN could not see much reason to alter his opinion expressed in a homely way at the meeting in Hamilton, that the two fans were six and half-a-dozen. As Mr Beith very properly remarked, it was more a question of airways than the difference of the fans. Practically they would find that the work done by any engine in driving the fan was but a very small proportion of the work necessary to drive the quantity of air through the fan if there was no resistance in the mine,—in some cases only five per cent., in others more. All that tended to show the necessity for large areas of air-courses, short rounds, and as many of them as they could get. These were of far more importance in determining the quantity of air than the difference between the best fan and the worst, or between a forcing fan and an exhausting fan. One great benefit the fan had brought about was that it had taught them to look to the proper means of getting quantity.

In a furnace they never attempted to get a 3-inch water-gauge, because in their shallow pits that was an impossibility, and many of them were disappointed with the small additional quantity that fans gave. He saw a very useful work the other day—the translation of a French work by Mr Steavenson, Durham, giving the theory of fans. The mathematics were not very deep, and he thought some of their members, especially the younger portion who had a better chance of going through mathematics than many of them, might look at it and study it with care. Mr Moore concluded by asking a vote of thanks to Mr Beith and to the committee for their experiments, which was heartily accorded.

DISCUSSION OF MR BEILBY'S PAPER ON YOUNG AND BEILBY'S PROCESS FOR THE TREATMENT OF COAL.

The CHAIRMAN, in introducing the discussion on this paper, remarked that this system had been introduced by the late Lord Dundonald, who was ridiculed for his Tar Retort at the beginning of the century, and it had lain aside until it had been brought to the front again.

Mr PRENTICE said—Mr Beilby has suggested towards the end of his very able and interesting paper that the process which he describes should be adopted by coalmasters to work up the small coal at their pits. I have been trying to make a practical estimate of the results of such an attempt; but have had some difficulty in arriving at any specific conclusion, for a similar reason to that pointed out by Mr Rowan at our last meeting, namely, that we have no definite statement of the costs of applying or working the process. Mr Beilby has given us a statement of the results obtained from actual working on a large scale at the Pentland Works. He has also given us a statement of certain results, which he says have been pointed to in some experiments that have been wrought at Oakbank, and which shew 10s 10d to be derived from the incineration of one ton of dross; and he has also given another estimate of applying the process to gas-works, shewing the value

of the results from a ton of dross to be 15s 5d. Now, I wish to say in the first place that I am not very sanguine as to the value of estimates based on mere experiments; as I know that it has been often found that the results obtained in working practically on a moderate scale are very disappointing when compared with the results of experiments made on a small scale and carried out in the most careful manner. I may say further that it seems to me that in estimating the value of the tar obtained, where dross has been distilled along with steam, the price of 2½d per gallon is far too high. It is well known that such tar contains little or none of the most valuable product of gas-work tar, viz., benzole, and I believe that not more than 1d per gallon could be obtained for any such tar in the market at present. Of the three statements of results given us by Mr Beilby to which I have referred, two of them (those shewn on pages 171 and 173) are theoretical only; and on that account not of the same value as the statement of results obtained at the Pentland Works (page 169), where the process is being wrought in a practical way, and the following appear to be the results so far as I can estimate them obtained from one ton of dross at Pentland:—

	s.	d.
45 lbs. Ammonia, at 1d per lb., ...	3	9
10 gallons Tar, at 1d per gallon, ...	0	10
	4	7

The cost of obtaining this 4s 7d I estimate as follows:—

	s.	d.
Labour, including Retortmen, Enginemen, Sulphate of Ammonia Maker, &c., &c., per ton, ...	2	6
Interest on Capital and Taxes, ...	0	6
Tear, Wear, and Depreciation, ...	1	6
Royalty on Patent, 10 per cent. of excess of Ammonia,	0	3
	4	9

This shews that, without reckoning the value of the dross, the cost of labour, &c., would exceed by 2d per ton the value of the products obtained. But against this must be set the spare heating gas and coke, available after heating the retorts themselves—the boilers and ammonia plant—but whether these would be more valuable than the dross, originally, I am not clear. I estimate the cost of plant, including retorts with condensers, superheaters

boilers for raising steam, scrubber, pumps, fan, engine, and ammonia plant, tar and water tanks, &c., to be £130 for every ton of dross wrought per day. I do not think this is an over estimate, as I know it has cost more than this to erect similar works on a pretty large scale at a colliery in this neighbourhood. I estimate the work to be renewed every 6 years: and if the tear and wear is considered fully, I am afraid that the cost for this has been under estimated. Mr Beilby states that the cost of the plant being erected at Oakbank is about £80 per ton of coal per day; but I am not sure if he includes in this estimate the whole of the ammonia plant, or the engine boilers, tar and water tanks, which would all have to be put down specially for this purpose if a coalmaster were to go into the process. As regards the costs of labour, I have based the calculation on plant being erected to work 20 tons per day. I think that 20 tons per day is as much as any coalmaster could erect, and at the same time utilise the spare heating gas at his pits; and it is I think quite clear that where the spare gas cannot be utilised there would be an actual loss on the process. I have based the calculation of the value of the results on ammonia selling at £14 10s at the shipping port; but as the price to-day is at least £1 per ton less, this makes a difference of 5d per ton on the value of the results; and if ammonia fall another £1 per ton, as many people think very probable, this would reduce the value of the results by 10d per ton of dross wrought. However this may be, I fear the margin is not such as to induce at present many coalmasters to go into the process; more especially as it certainly involves a very large expenditure of capital in proportion to the amount of coal or dross used.

Mr GORMAN, who was invited by the Chairman to take part in the discussion, said the obtaining of ammonia did not seem to him to be a subject that was of so much importance, unless it was taken in connection with the use of coal for obtaining heat, and for other purposes; but he thought if they got their ammonia for nothing, and their tar simply for the collecting, when they were using coal at any rate for smelting or working iron, or in connection with furnaces and steam boilers, it did come to be a thing worth looking after. To employ this system for the purpose of

using small coal, unless it should be used as coke to be sold, would, he thought, scarcely pay the expense. They had had very interesting experiments going on in Ireland for converting peat into by-products, and if there was any real good or big amount of money to be got out of it, he believed it would have come to the front long before this time.

The CHAIRMAN said notwithstanding the not very sanguine reports of the two gentlemen who had addressed them, the subject was being very much looked after; but it was a subject on which there was a great deal to be said and learned. It certainly would be a very great matter if dross, which they threw away in a great measure, could be utilised, and if the results such as given there could be any way nearly obtained. There was not a coal-master but would be trying it to-morrow if he had faith in it. They could not blind their eyes to the fact that there was a Company starting at Ayr Road, laying out a very great deal of money, for the purpose of utilising these by-products; and there were already in existence, he was told, works using dross for the purpose. He was not chemist enough himself to say, but he knew, notwithstanding what Mr Prentice had said, that the getting of benzole from coal-tar was contemplated. He believed Mr Beilby would be able to put them right as to that.

Mr MORRISON, referring to Mr Beilby's statement on p. 169 as to the economical use of his process in distilling shale, asked if Mr Beilby would anticipate in firing boilers the same economical results.

Mr ROWAN said he had received a number of practical questions from Mr Maclaren Irvine, who intended to be there; but as he was not able to be present, he had asked him (the speaker) to put them.

Mr IRVINE asked—(1) What number of retorts will one Lancashire boiler, 25′ 0″ long by 7′ 6″ diameter, supply, when evaporating 8 lbs. of water per 1 lb. of fuel? (2) At what temperature do the escaping gases pass away into the flue leading to the chimney, after leaving the superheater? According to the tables VI. and IX., pages 178 and 181, it appears that to fully incinerate the coal 7911 lbs. of steam are necessary; but, when only 50 per cent. is incinerated, only 4698 lbs. of steam are required. If such

an excess quantity of steam (3213 lbs.) is necessary to fully incinerate the coal, can this be done with economy; and, if the incineration is carried on to 50 per cent. only, how is the residual coke to be disposed of in a district where there is no demand for it, and where all the firing in the works is done by means of gaseous fuel? (3) If this residual coke is to be converted into gaseous fuel by one of the ordinary gas producers, will not the increased amount of ash contained in the fuel which is used for charging it necessitate more frequent cleaning? (4) What would be the actual cost of incinerating each ton of coal, supposing 50 to 100 tons were consumed per day? (5) What is the capability of each retort—*i.e.*, what quantity of coal will it convert into gaseous fuel, *(a)* when fully incinerated, and *(b)* when the incineration is carried out to only 50 per cent.; and what would be the approximate cost of the necessary plant, in complete working order, to incinerate the above quantity (50 to 100 tons); and what would be the oncost charges for labour? (6) What life have these retorts; and is there any liability to breakage or frequent stoppage for repairs? (7) As the incineration is (practically) carried on by exterior heat, what amount of fuel is necessary for each ton incinerated?

The CHAIRMAN said if Mr Beilby liked to take the trouble of answering these questions they would be delighted to have them at his leisure.

Mr ROWAN said he wished to remark on Mr Beilby's paper, for his own part, how greatly he was delighted with so clear and able a paper on the subject. At the same time he thought he had reason to complain a little, because, in dealing with the fuel-gas industry, Mr Beilby confined himself entirely to the system of gas producers which worked by, as he said, admitting a regulated quantity of air into a brick-lined combustion chamber—the gas so produced being cooled in iron mains so as to insure partial condensation of the tars. In this process there is the loss, as Mr Beilby showed, of a considerable amount of heat. The system of gas producing, which he (the speaker) had the honour of bringing before the Institute in a paper some time ago, is worked somewhat differently, as they were aware, both as to the purpose for which steam is used and in respect of the fact that the

gas is led away under pressure and used hot, so that the loss of heat alluded to by Mr Beilby is avoided. Moreover, he hoped to show them this evening a further improvement in the Wilson system, by which not only was the hand-labour of cleaning out, which the old producer required, saved by the substitution of mechanical appliances for continuously removing ashes and clinker, but also as the refuse matter fell into a trough containing water at the bottom of the producer, and was passed up the shoot to the outside cooled down to 150 degrees Fahr., the heat which was usually lost by the withdrawal of red hot, and almost white hot ashes and clinker was entirely prevented, that heat being actually "regenerated" within the producer itself. The steam formed by the evaporation of the water in this way rose up through the glowing fuel where it was decomposed, adding hydrogen and carbonic oxide to the producer gas. There was one point about which he should like to ask Mr Beilby a question. Mr Beilby was kind enough since last meeting to give him a copy of the interesting paper by Dr Grouven to which he referred in his paper, and on reading that pamphlet he (the speaker) saw that Dr Grouven spoke of the use of a material which he called "contactmasse" as being necessary for the extraction of all the nitrogen in coal or organic substances by his method. He did not understand what in Mr Beilby's process represented this material, as he had not noticed in Mr Beilby's paper any reference to a substitute, but he desired to be enlightened on that point. The use of this "contactmasse" seemed to be a vital point in Dr Grouven's method, and he would be glad if Mr Beilby would explain what in his process fulfilled the important purpose of that material, or how he was able to do without it.

Mr WADDELL said Mr Beilby in his paper gave them the one side of the question; shewed what could be got out of the process, but gave them no data as to the cost of the thing. The most of the questions referred to very much as to whether they had a large quantity of steam, as to whether they required a large amount of condensing power, and the cost of steam raised,—all very practical. This added very much to the cost, as they all knew very well. When men asked for a rise of wages, they were apt to point to the difference of price of coal f.o.b., and

the small sum they got for working it as all profit, forgetting or ignoring the many other charges before it got to the market. In like manner, Mr Beilby made it out to be all profit and shewed no cost. Now, it was well known there was a large amount of cost. He might also say, in confirmation of certain of the questions, and of what was stated as to the difference in what was got by experiment and in practice, that at the work with which he was connected they had been working with shale and he had not yet been able by a good way to come up to what had been got experimentally. Mr Beilby also stated in his paper certain results which had been got at Pentland, and other results which were simply pointed to. Now, of course, this new process might reach more than what had ever yet been got, but as far as he was aware,—and he had been talking to several persons on the subject,—what had been got at Pentland was as much as had ever been got practically. They seemed to save a large amount of fuel at Pentland in comparison with what they used at Oakbank. He would like to ask if this was not a great deal due to the shape of the Pentland retort,—that it was a larger retort, holding a greater amount of material, and getting a greater advantage from the heat than that at Oakbank. As to cost, while he had not been able fully to follow the figures given by Mr Prentice, he did not think it was over-stated at £130 per ton of coal used, as he knew a large company putting up plant specially to go into this trade, and he was led to understand they did not erect it for less than £130 per ton.

Mr BEILBY stated that from the nature of some of the questions put to him he could not be expected to reply off-hand, but he would be glad to prepare a reply and send it to the Secretary. Mr Beilby afterwards communicated the following :—

To simplify the replies to the criticisms of members who have spoken and written, I have classified these according to the subjects treated of; but before taking up these in detail, there are a few remarks of a more general character to make.

It is very natural that so practical a society as yours is, should at once seek to lay bare the commercial foundations on which the new process must ultimately rest; and I appreciate the clear and pointed criticisms of Messrs Prentice, Irvine, and Waddell

on this aspect of the subject. On the other hand, my intention in writing the paper was rather to give a comprehensive view of certain new facts and processes by themselves, and in their relation to facts and processes already known. The description was illustrated by the quotation of certain results which, however, were not intended as statements of profits, but were rather to show the materials out of which profit must come. In no case was a balance of cost and profit struck; it was believed that anyone likely to adopt the process would seek to verify all such statements by a study of the process at work commercially. To meet the evident wish of the members, I now supply a statement of "cost and profit" to compare with Mr Prentice's statement of "cost and loss"; and as I altogether agree with him as to the un-wisdom of basing commercial calculations on any but the results of prolonged working on a large scale, the results given below are those obtained in nine months' working of the coal retorts at Pentland Works.

The question of "gaseous versus solid fuel" has been before me for so many years, and the belief that the new process will materially help to settle the judgment on the side of the former was so strongly borne in upon me while writing the paper, that it influenced its whole form and character. Since reading the paper, and through the courtesy of Mr Rowan, I have had an opportunity of more fully studying the literature of the "Wilson Gas Producer" and am pleased to acknowledge that the description of fuel gas production on page 162 does not give an adequate idea of the most recent apparatus for the purpose. This is less to be regretted as you have had before you such complete descriptions of the apparatus from Mr Rowan himself.

The manufacture and use of fuel gas is one of the greatest, if not actually the greatest technical question of the day, and any consideration of the subjects brought before you in this paper must in my opinion be incomplete if this aspect is not fully recognised.

The questions to be answered refer to

1. *The steam required and the means of raising it.*
2. *The use of air mixed with steam.*
3. *The residual coke and its uses.*

4. *The consumpt of fuel and regenerative heating.*
5. *The capability of retorts.*
6. *The life of retorts.*
7. *The quality of tar.*
8. *Substitute for "Contactmass."*
9. *Costs and profits.*

1. *Steam required and the means of raising it.*

The steam used in the coal retorts at Pentland amounts to 1500 lbs. per ton of coal; it is obtained entirely from the exhaust of the engines in the works. The steam from a Lancashire boiler 25′ × 7′ 6″ exhausted through engines would probably give 50,000 lbs. of steam per day, sufficient at the above rate for the treatment of 33⅓ tons of coal per day.

With retorts of the form shown in figs. 2 and 3, we have obtained from a dross containing nitrogen equal to 115 lbs. of sulphate of ammonia per ton, 80 to 90 lbs., using for the treatment about 5000 lbs. of steam. At this rate, the beforementioned boiler would supply steam for the treatment of 10 tons of coal per day.

2. *The use of Air mixed with Steam.*

The advantages of such a mixture are these:—less heat has to be supplied to the coal from without; less steam is needed; and the plant can put through more coal than when steam alone is used. The disadvantages are—the great volume of gas which has to be cooled and scrubbed; and the dilution of the gas by the nitrogen of the air used.

The Pentland coal retort happily combines steam and air incineration so as to gain as far as possible the advantages without the disadvantages. The yield of ammonia hitherto obtained, namely 45 pounds of sulphate per ton, is by no means the maximum obtainable. By some alterations which Mr Young is at present making, we hope to get higher yields with little, if any, increase of cost.

3. *The Residual Coke and its Uses.*

The value of the cinder will depend on three things:—the nature of the coal used, the amount of its fixed carbon incinerated,

and the distance of the work from a suitable market. If the use of coke gas producers extends, as we believe it will, there will always be a demand for cinder coke at a price at least equal to that obtainable for good dross.

If the material to be handled were the refuse dross of the pit-head, having no intrinsic value as it stood, its whole heating value might wisely be sacrificed to obtain a maximum yield of products.

In working this coke in gas producers, no serious difficulty is caused by the increased per centage of ash. The ordinary precautions to prevent the formation of large clinkers are, of course, always observed. When dross from, very dry coal is treated, the resulting cinder may have to be riddled to get rid of the fine dust which would otherwise be apt to choke the producer.

4. *Consumpt of Fuel and Regeneration.*

In the Pentland coal retorts the gain of efficiency by the gasification of the fuel more than compensates for the expenditure of heat in effecting the gasification.

In other cases it is estimated that 25 per cent. of the heat value of the coal may have to be sacrificed for its treatment by the process.

On Fig. 1 an exchanging regenerator TT is shown. The retorts in Figs. 2 and 3 were at first designed with a somewhat similar arrangement, the air for combustion being heated by passing through iron pipes in the flue chamber M, M, but for certain reasons this plan was departed from, and the steam superheaters are placed in this chamber. In erecting any more retorts of the same kind, I intend to arrange a brick exchanging regenerator in the chamber above W in Fig. 2. The gases at present leave the main flue at a temperature slightly over the melting point of zinc.

5. *The Capability of the Retorts.*

Each of the retort producers shown in Fig. 1 distils and gasifies completely 13 cwts. of dross per 24 hours.

6. *The Life of Retorts.*

Retorts built as in Figs. 2 and 3 have been in use at Oakbank

for nearly two years, and seem to-day as good as when they were built. It is of great importance to select a suitable fire-clay. In some cases bricks made of improper clay have completely given out within a year.

In these retort benches the chief wear and tear will occur in the gas producer, which may have to be re-lined occasionally. Fortunately, this is a simple operation, and involves no destruction of the main building. The building and its retorts are likely to run for years without replacement, as the steady, uniform heating by gas is very favourable to a long life for retorts and brickwork. When replacement is required, only the retorts themselves will need to be re-built, and the cost of these does not amount to more than from five per cent. to seven per cent. of the total cost of plant.

7. *The Quality of the Tars.*

When the process is carried out in conjunction with the manufacture of illuminating gas (p. 170) the ordinary products will be obtained. When carried out in the retorts (figs. 2 and 3) the passage of the vapours through several feet of red-hot coke decomposes the hydro-carbons of the paraffin and olefin series, giving tars and gases rich in benzol. The tar from the Pentland coal retorts is of an intermediate character, and is therefore of less value.

In the specification of a patent granted to us in 1882 an apparatus is shown specially designed to give maximum yields of benzol and ammonia.

8. *Substitute for "Contactmass."*

In the retorts (figs. 2 and 3), the distillation being effected at the top, the vapours have to pass down through coke at a moderate red heat, and being accompanied with steam are to a great extent decomposed with formation of ammonia. The decomposition is not as carefully regulated, and is therefore not as perfectly carried out, as is the case with Grouven's ammonium ovens with "contactmass," but the action is roughly the same.

9. *Costs and Profits.*

As these retorts take the place of coal furnaces for heating the benches of shale retorts, the profit of working will be got at by a comparison of these two methods of heating.

In Coal Furnaces One Ton of Coal will Cost—

	s.	d.
Emptying coal from railway waggons and charging into furnaces, cleaning furnaces and removing ashes, - - - - -	0	9
Relining furnaces and cleaning flues, - - - - - - - -	0	2
	0	11

In Coal Retorts One Ton of Coal will Cost—

	s.	d.
Emptying coal from railway waggons and charging retorts, - -	0	6
Cleaning and removing ashes and attending to heats, - - -	0	10
Repairs to combustion chambers and retorts, - - - - - -	0	4
Interest and ledger depreciation on plant expenditure of say £100,	1	0
Royalty, - - - - - - - - - - - - - - -	0	3
	2	11
Deduct furnace costs, - - - - - - - - - - - -	0	11
Extra costs of retorts, - - - - - - - - - - -	2	0

And against this extra cost there is obtained—

	s.	d.
45 lbs of sulphate of ammonia, at £9 6s 8d per ton net = 1d per lb.,	3	9
10 gallons of tar, at 1d, - - - - - - - - - - -	0	10
	4	7

or a clear profit of 2s 7d per ton.

The steam for the process being obtained from the exhaust from the engines costs nothing. The cost of making sulphate is taken at £4 per ton, which is very ample.

From the results quoted on p. 169, we are entitled to assume that a ton of coal treated in these retorts will give a heating effect greater than that obtainable from the same coal burned in an open furnace.

The discussion was adjourned.

On GAS FIRING for STEAM BOILERS, by MR F. J. ROWAN.

The quantities of fuel consumed each day in boiler furnaces are considerable, and the expenditure occasioned in all industries by the production of motive power is too great not to attract our attention and to cause us to seek diligently for means of applying to boilers gas firing with all its advantages.

Great advance has been made in the design of boilers in the direction of utilizing more perfectly the heat of the gaseous products of combustion, and in that of reducing the diameters which are subject to pressure so that thinner material can be used for a large portion of the heating surface; and thus the transmission of heat, as well as the cooling of the gases, is facilitated. But a similar advance has only recently been made in perfecting the means of combustion and in the application of the fuel, so that still, in spite of police regulations about the production of smoke, the chimneys of many works and factories send forth great volumes of dense black smoke, polluting the surrounding atmosphere.

In order to have complete combustion it is necessary to have an intimate mixture and contact between the particles of the combustible and the oxygen of the air, and to maintain, during the whole period of combustion, a temperature sufficiently high to permit of the free action of chemical affinity.

The employment of solid fuel, although in small pieces, prevents the realization of the one because it is only the *surface* of the pieces which can be in contact with the air; and the employment of methods of combustion which necessitate the use of excess of air interferes with the other by the inevitable lowering of the temperature.

Mere alterations of the form of the grate and of the methods of charging the fuel upon it do not suffice to meet the problem; and thus mechanical stokers must fail to be permanently adopted, since they only deal with the evil of irregular charging. On the other hand, the mere prevention of the *appearance* of smoke is not

all. Analysis of the escaping gases is required to show whether there is an excess of oxygen in them, and thus whether too much air is being admitted to the fire, and also to prove whether the invisible gases do not contain carbonic oxide instead of carbonic acid, shewing that fuel is being wasted. This test is especially needed to expose the fallacy of those so-called "smoke consumers," which propose to give completeness of combustion by the introduction of steam into the furnaces in which coal is being burned.

A furnace approaches perfection in proportion as the fuel is burned in it completely and with the minimum quantity of air in excess. Smoke escaping from the chimney is the best proof that combustion is incomplete, and if we could tell by sight the composition of the gaseous mixture in which the smoke is suspended we should see that air is nearly always present in great excess. This excess of air is detrimental, because it lowers the temperature of the gases of combustion at the expense of which it is heated, and renders it necessary to increase the heating surface of any apparatus designed to utilize the heat of such gases. It also involves the construction of larger grates than are theoretically necessary, thus causing increased cost of construction; and as the gases which escape from the chimney must possess a certain temperature, the quantity of heat lost in this way is proportional to the quantity of gas passing away.

To apply this to the case of steam boilers, it is plain that the excess of air admitted to the furnace cools the flame, lessens the production of steam per square foot of heating surface, and necessitates an increase of surface in the boiler in order to obtain a given production of steam and reduction of the temperature of the hot gases. Moreover, if we admit a temperature of chimney of 200° C (= 392° Fahr.) for a medium draught, then if we employ two or three times the quantity of air theoretically required by the fuel, the loss of heat in this direction is double or treble the normal or proper loss. The chimney itself, so as to discharge more gas than would be necessary with furnaces constructed to work without excess of air, must have larger dimensions; and as that happens only too often we are led to cool the gases less and lose them at 300° or 400° C. (500° or 700° Fahr.) in order to get sufficient draught with these larger chimneys.

The evils inherent in furnaces using solid fuel are not to be overcome by management of the draught or alteration of the speed of combustion. For a comparison of the different rates of combustion per standard area of grate surface with ordinary appliances shows that with slow combustion on large grates with feeble draught, no greater useful effect is obtained than with smaller grates on which a larger quantity of fuel is incompletely burned with a strong draught.

Again, with imperfect combustion such as is common to all boiler furnaces using solid fuel, we are exposed to the evil of the formation of a deposit of soot on the heating surfaces of the boilers (and feed-water heaters where these are used), which entails a considerable loss of their efficiency. And the use of solid fuel also causes additional wear to the boilers by the alternate heating and cooling which result from the operations of charging where solid fuel must first be volatilized and then burned in the same chamber, and even of combustion itself.

Gas firing is the easy remedy for all those evils, and it fulfils in a remarkable degree the conditions necessary for obtaining the best result from the combustion of fuel. By no other means can that intimate mixture and contact between the particles of the combustible and the supporter of combustion be obtained which are essential to complete combustion. The formation of smoke and soot is prevented, and, in the case of boilers, the destructive alternations of high and low temperature are replaced by an even temperature which the steady stream of flame supplies.

In carrying out the application of gas to boiler firing, some simple precautions are desirable. For instance, in consequence of the rapid cooling of the products of combustion which results from contact with the surfaces of boilers which continually abstract heat, it is necessary in firing them with gas to allow the gas and air to mix in a combustion chamber previous to their entrance into boiler flues, so that only flame and highly heated products of combustion come in contact with the heating surface.

Heating the supply of air for combustion by means of the waste heat carried by the escaping gases insures a higher temperature of combustion; but with gas firing, even without such an addition, it is possible not only to insure the use of the minimum

quantity of air in excess, but also to obtain a higher calorific intensity than with solid fuel. The reason of this is clearly explained by Galloway in his *Treatise on Fuel*, where he says (p. 46): —"For every 1 part by weight of oxygen contained in air, there are 3·35 of nitrogen; now, 8 parts of oxygen are required to convert 3 parts of carbon into carbonic acid: there are associated with the 8 parts of oxygen in the air 26·8 parts of nitrogen, and the specific heat of nitrogen is 0·244 at constant pressure. We find the calorific intensity when carbon is burned in air to be 2717·6° C. thus:—

$$\frac{3 \times 8080}{11 \times 0{\cdot}2164 + 26{\cdot}8 \times 0{\cdot}244} = 2717{\cdot}6^\circ \text{ C.}$$

Paradoxical as it might at first appear, the calorific intensity of carbonic oxide is greater than that of carbon when burnt in air. It will be seen that this is due to the lesser amount of air the carbonic oxide requires for its combustion, thus:—

$$\frac{2403}{1{\cdot}57 \times 0{\cdot}2164 + 1{\cdot}91 \times 0{\cdot}244} = 2982^\circ \text{ C.}"$$

The subject of firing boilers by gas has been studied on the Continent for a number of years; and, in the year 1873, after numerous trials, very satisfactory results were realised in actual working in France.

These results were obtained in the works of M. E. Muller at Ivry, and are recorded in an excellent paper by M. Fichet in the *Memoires de la Societé des Ingenieurs Civils*, the information of which paper has been freely made use of for the purposes of this communication. Two boilers were employed of the French type, having the cylindrical portion 1 m. 10 (= 3ft. 7in.) diameter, with heaters or accessory chambers 60 centim. (= 24in.) diameter, and the heating surface was 52 square metres (= 560 square feet) not reckoning the surface of feed-water heaters.

A producer (or gazogène) of a modification of the Siemens type was employed, placed close to the boiler setting—in fact, the arrangement required a producer grate to each boiler—and the setting contained elaborate passages for dividing and heating the air used for combustion. The performance of the gas-fired boiler was compared with that of the one fired by hand, and with

similar boilers fired by hand using the same coal and the same water, and numerous analyses were made of the producer gas and escaping gases after combustion.

It was found that, whereas the ordinary rate of evaporation in hand fired boilers—using the coal of the north of France and of Belgium—was about 6 lbs. of water per lb. of coal (although the Industrial Society of Mulhouse recorded in July, 1873, several results varying from 6·018 to 6·448 lbs), with the gas fired boiler an evaporation of 8·60 and 9·20, or a mean of 8·90 lbs. was obtained. This showed an increase of evaporative efficiency of 48 per cent. in the boiler fired by gas, or an economy of fuel of 38 per cent. for equal quantities of water evaporated.

Great stress is laid by M. Fichet upon the importance of having a supply of heated air under a slight pressure (due to the ascensional force acquired by its being heated), so that there should be no suction from chimney draught, which, he found, invariably caused an excess of air to find its way in through cracks in the brickwork, and even through the pores of the bricks themselves, even when all air valves were closed. It is to be remarked, however, that the arrangement of gazogene and boiler setting which he adopted necessitated a large amount of brickwork.

He has not given the temperature to which the air for combustion was heated, but other observations, extending over a week's working, are given in tables of which the following are translations :—

RESULTS OF THE WORKING OF GAS-FIRED BOILERS.

Description of Coal used, ... Grand Hornu.

Moisture in Coal (in the rough), ... 2·21%

Analysis of Coal (dry) { Gas, 27·72 / Coke, 72·28 } .. .. 100·00.

Ash, ... 9·36%

Heating Surface of Boiler, ... 52 sq. met. = 559·74 sq. ft.

Average pressure of Steam, ... 5 atmos. = 75 lbs per sq. in.

Weight of Coal burned in 11 hours, ... 820 kil. = 1808 lbs.

„ Water evaporated in 11 hours, ... 6,900 kil. = 15,224 lbs.

„ „ „ per lb. fuel, ... 8·40 lbs.

„ „ at 0°C (= 32° F.) .. .. 8·80 lbs.

„ „ evaporated per sq. met. of surface, ... 12·0 kil.

„ Ashes (dry) in 11 hours, ... 72 kil. = 158·7 lbs.

Hour of Observation.	Temperature of Feed Water in Tank.	Analyses of Gases.						Temperatures Observed. Degrees Centigrade.			
		Place where Sampled.	CO_2	O.	CO.	N, &c.	Total.	Between Boiler and Heaters.	At the End of Boiler.	In Front of Feed Water Heater.	Behind the Feed Water Heater.
	Deg. Cent.										
6 a.m.	24	..	..	..	..	..	..	625	..	..	..
7 a.m.	(75·2 F.)	Gasogene	..	..	..	100	100	..	..	..	..
		Combust. Chamber	16	..	..	84	100	..	..	..	..
		End of Boiler ..	17·5	..	..	82·5	100	..	..	..	..
8 a.m.	..	Gasogene	1	..	..	99	100	..	336	332	262
		Combust. Chamber	17	..	..	83	100	..	..	..	..
		End of Boiler ..	16·5	..	..	83·5	100	..	..	..	..
10 a.m.	..	Gasogene	..	..	..	100	100	626	..	..	..
		Combust. Chamber	16	..	..	84	100	..	..	..	..
		End of Boiler ..	16·5	..	..	83·5	100	..	326	321	..
12 noon.	24	..	..	..	..	..	..	..	..	..	..
2 p.m.	..	Gasogene	1	..	..	99	100	490	..	..	..
		Combust. Chamber	18·5	..	..	81·5	100	..	..	..	..
		End of Boiler ..	16·5	..	..	83·5	100	..	398	358	..
4 p.m.	..	Gasogene	..	..	..	100	100	..	..	..	263
		Combust. Chamber	16	..	..	84	100	708	..	..	..
		End of Boiler ..	15	..	..	85	100	..	..	..	..
6 p.m.	29 (84·2 F.)										

Note.—$\frac{\text{Deg. Cent.} \times 9}{5} + 32 = \text{deg. Fah.}$

Kilograms × 2·2046 = lbs.

RESULTS, &c.—*Continued.*

Description of Coal used, ...	Grand Hornu.
Moisture in Coal (in the rough), ...	2·21 %
Analysis of Coal (dry), {Gas, 27·72 / Coke, 72·28}	100·00 ,,
Ash, ...	9·36 ,,
Heating Surface of Boiler, ...	52 sq. met. = 559·74 sq. ft.
Average pressure of Steam, ...	4·5 atmos. = 66 lbs. p. sq. in.
Weight of Coal burned in 11 hours, ...	818 kil. = 1803 lbs.
,, Water evaporated in 11 hours, ...	6,845 kil. = 15,086 ,,
,, ,, ,, per lb. fuel, ...	8·37 ,,
,, ,, at 32°F., ...	8·83 ,,
,, ,, evap. per sq. met. of surface, ...	12·0 kil.
,, Ashes (dry), in 11 hours, ...	76·5 kil. = 168·6 lbs.

Hour of Observation.	Temperature of Feed Water in Tank.	Analyses of Gases.						Temperatures Observed. Degrees Cent.			
		Place where Sampled.	CO_2	O.	CO.	N, &c.	Total.	Between Boilers and Heaters.	At the end of Boiler.	In front of Feed Water Heater.	At back of Feed Water Heater.
	Deg. Cent.										
6 a.m.	27										
7 a.m.	(80·6 F).	Gasogene..	0·5	..	..	99·5	100	..	..	..	..
		Combust. Chamber	16·5	..	..	83·5	100	..	..	..	..
		End of Boiler ..	17	..	..	83	100	610	375	..	..
9 a.m.	..	Gasogene..		..	..	100	100	..	..	401	..
		Combust. Chamber	17	..	..	83	100	..	..	..	..
		End of Boiler ..	15	..	..	85	100	626	352	342	..
12 noon	..	Gasogene..	0·5	..	..	99·5	100	..	..	..	300
		Combust. Chamber	13	..	..	87	100	..	..	..	..
		End of Boiler ..	13·5	..	..	86·5	100	..	..	..	..
1 p.m.	25	..	..	..	..	..	..	629	368	342	..
3 p.m.	(77° F).	Gasogene..	0·5	..	..	99·5	100	..	..	..	..
		Combust. Chamber	14·5	..	..	85·5	100	..	..	..	..
		End of Boiler ..	16	..	..	84	100	682	370	..	..
5 p.m.	..	..	..	..	..	..	..	..	..	329	..

RESULTS, &c.—*Continued.*

Description of Coal used, ...	Grand Hornu.
Moisture in Coal (in the rough), ...	2·21 %
Analysis of Coal (dry) {Gas, 27·72 / Coke, 72·28}	100·00 ,,
Ash, ...	9·36 ,,
Heating Surface of Boiler, ...	52 sq. met. = 559·74 sq. ft.
Average Pressure of Steam, ...	5 atmos. = 75 lbs. p. sq. in.
Weight of Coal Burned in 11 hours, ...	...911 kil. = 2007 lbs.
,, Water evaporated in 11 hours, ...	7850 kil. = 17,301 lbs.
,, ,, ,, per lb. fuel, ...	8·61 lbs.
,, at 32°F., ...	9·08 lbs.
,, Water evaporated per sq. met. of surface, ...	13·72 kil.
,, Ashes (dry) in 11 hours, ...	89 kil. = 196 lbs.

Hour of Observation.	Temperature of Feed Water in Tank.	Analyses of Gases.						Temperatures Observed. Degrees Centigrade.			
		Place where Sampled.	CO_2	O.	CO.	N, &c.	Total.	Between Boiler and Heaters.	At the End of Boiler.	In Front of Feed Water Heater.	At Back of Feed Water Heater.
6 a.m.	Deg. Cent. 24 (75·2F.)										
8 a.m.		Gasogene	0·5	...	...	99·5	100	648	...	...	...
		Combust. Chamber	17	...	...	83	100	...	...	...	...
		End of Boiler ...	16	...	...	84	100	...	...	...	...
10 a.m.	...	...	...	...	...	...	...	...	365	356	...
3 p.m.	...	Gasogene	...	...	21	79	100	...	...	...	...
		Combust. Chamber	9	9	1	81	100	...	...	...	...
		End of Boiler ...	14·5	4	1	80·5	100	577	...	...	...
5 p.m.	...	...	...	...	...	...	...	...	410	417	...
6 p.m.	31 (87·8F.)										

RESULTS, &c.—*Continued.*

Description of Coal Used, ...	... Nœux, Pit No. 4.
Moisture in Coal (in the rough), ...	2·01%
Analysis of Coal (dry) {Gas, 28·87 / Coke, 71·13}	100·00 ,,
Ash, ...	6·42 ,,
Heating Surface of Boiler, ...	52 sq. met. = 559·74 sq. ft,
Average Pressure of Steam, ...	4·75 atmos. = 69·85 lbs.
Weight of Coal Burned in 11 Hours, ...	1031 kil. = 2272 ,,
,, Water Evaporated, in 11 Hours, ...	8810 kil. = 19,417 ,,
,, ,, ,, per lb. Fuel, ...	8·54 ,,
,, ,, at 32° F., ...	9·33 ,,
,, ,, Evaporated per sq. met. of surface, ...	15·40 kil.
,, Ashes (dry), in 11 Hours,...	126 kil. = 277·7 lbs.

Hour of Observation.	Temperature of Feed Water in Tank.	Analyses of Gases.						Temperatures Observed. Degrees Cent.			
		Place where Sampled.	CO_2	O.	CO.	N. &c.	Total.	Between Boiler and Heaters.	At the End of Boiler.	In Front of Feed Water Heater.	At Back of Feed Water Heater.
6 a.m.	Deg. Cent. 28 (82·4 F.).										
8 a.m.		Gasogene...	1	...	20	79	100	...	...	...	...
		Combust. Chamber	8·5	5·5	2·5	83·5	100	...	...	...	...
9 a.m.	...	,,	11	9	0	80	100	613	...	...	...
10 a.m.	...	End of Boiler ...	11	2	5	82	100	...	384	...	...
11 a.m.	...	Combust. Chamber	14	5	0·5	80·5	100	...	...	336	...
3 p.m.	26 (78·8 F.).	Gasogene...	0·5	0	20	79	100	...	...	...	...
		Combust. Chamber	13	5·5	0·5	81	100	676	...	...	...
		End of Boiler ...	6·5	9·5	0·5	83·5	100	...	351	...	193
5 p.m.	...	Combust. Chamber	15	3·5	0	81	100	...	...	349	...
6 p.m.	30 (86· F.).										

RESULTS, &c.—*Continued.*

Description of Coal used, ...	Nœux—Pit No. 4.
Moisture in Coal (in the rough), ...	2·01 %.
Analysis of Coal (dry) {Gas, 28·87} {Coke, 71·13}	100·00 %.
Ash, ...	6·42 %.
Heating Surface of Boiler, ...	52 sq. met. = 559·74 sq. ft.
Average Pressure of Steam, ...	5 atmos. = 75 lbs. per sq. ft.
Weight of Coal burned in 11 hours, ...	1,127 kil. = 2,483·9 lbs.
,, Water evaporated in 11 hours, ...	11,858 kil. = 26,135 lbs.
,, ,, ,, per lb. fuel, ...	10·52 lbs.
,, ,, at 32° F., ,, ...	11·39 lbs.
,, ,, evaporated per sq. met. of surface, ...	20·73 kil.
,, Ashes (dry) in 11 hours, ...	...101 kil. = 222·6 lbs.

Hour of Observation.	Temperature of feed water in Tank.	Analyses of Gases. Place where sampled.	CO_2	O.	CO.	N., &c.	Total.	Temperatures observed. Degrees Cent. Between Boiler and Heaters.	At the end of Boiler.	In front of Feed Water Heater.	At back of Feed Water Heater.
	Deg. Cent.										
6 a.m.	25 (77 F.)	... ...	...	...	...	...	...	...	...	...	...
8 a.m.	...	Gasogene ...	1	0	20	79	100	...	...	...	...
...	...	End of Boiler	15	2	2	81	100	...	...	...	...
9 a.m.	...	Combust. Chamber	19·5	1	0·5	79	100	751	...	...	...
10 a.m.	...	,,	16	0	2	82	100	...	396	350	244
11 a.m.	...	End of Boiler	16	2	0	82	100	...	...	...	...
12 noon.	32 (89·6 F.)	... ...	...	...	...	...	...	...	...	...	...
3 p.m.	...	Combust. Chamber	16	0·5	0·5	83	100	...	...	...	...
...	...	Gasogene ...	5	0	16	79	100	...	...	...	...
...	...	End of Boiler	14	4	0	82	100	...	...	...	...
4 p.m.	...	Gasogene ...	0	0	21	79	100	686	...	...	...
5 p.m.	...	... ...	...	...	...	...	...	...	397	376	219
6 p.m.	31 (87·8 F.)	... ...	...	...	...	...	...	...	...	...	...

RESULTS, &c.—*Continued.*

Description of Coal used, ...	Nœux, Pit No. 4.
Moisture in Coal (in the rough),...	2·01 %
Analysis of Coal, dry {Gas, 28·87 / Coke, 71·13}	100·00 ,,
Ash, ...	6·42 ,,
Heating Surface of Boiler, ...	52 sq. met. = 559 74 sq. ft.
Average Pressure of Steam, ...	5 atmos. = 75 lbs. per sq. in.
Weight of Coal burned in 11 hours, ...	833 kil. = 1829·9 lbs.
,, Water evaporated in 11 hours, ...	7815 kil. = 17,246 ,,
,, ,, ,, per lb. fuel, ...	9·39 ,,
,, ,, at 32° F.,...	10·12 ,,
,, ,, Evaporated per sq. met. of surface, ...	13·70 kil.
,, Ashes (dry) in 11 hours, ...	99 kil. = 218 lbs.

Hour of Observation.	Temperature of feed water in Tank.	Analyses of Gases. Place where Sampled.	CO_2	O.	CO.	N, &c.	Total.	Temperatures Observed. Degrees Cent. Between Boiler and Heaters.	At the end of Boiler.	In front of Feed Water Heater.	At back of Feed Water Heater.
	Deg. Cent.										
8 a.m.	26	Gasogene..	..	..	20	80	100	...	...	...	...
9 a.m.	(78·8 F).	Combust. Chamber	15	1	0·5	83·5	100	610	...	...	...
10 a.m.	..	End of Boiler ..	15	4	0	81	100	...	355	305	210
1 p.m.	28	Gasogene..	0·5	0	20·5	79	100	...	...	...	...
	(82·4 F).	Combust. Chamber	13	1	4	82	100	...	...	...	...
2 p.m.	...	End of Boiler ..	15	1	3	81	100	659	...	...	...
3 p.m.	..		..	..	...	..	...	..	406	381	191
4 p.m.	..	Combust. Chamber	13	1	4	82	100	...	...	...	...
		Gasogene..	1	..	19	80	100	...	...	...	...
5 p.m.	..	Combust. Chamber	17	..	1	82	100	...	...	...	...
6 p.m.	30		..								
	(80° F).										

GAS FIRED BOILERS

To illustrate Mr Rowan's Paper on "Gas Firing for Steam Boilers."

FIG. 1

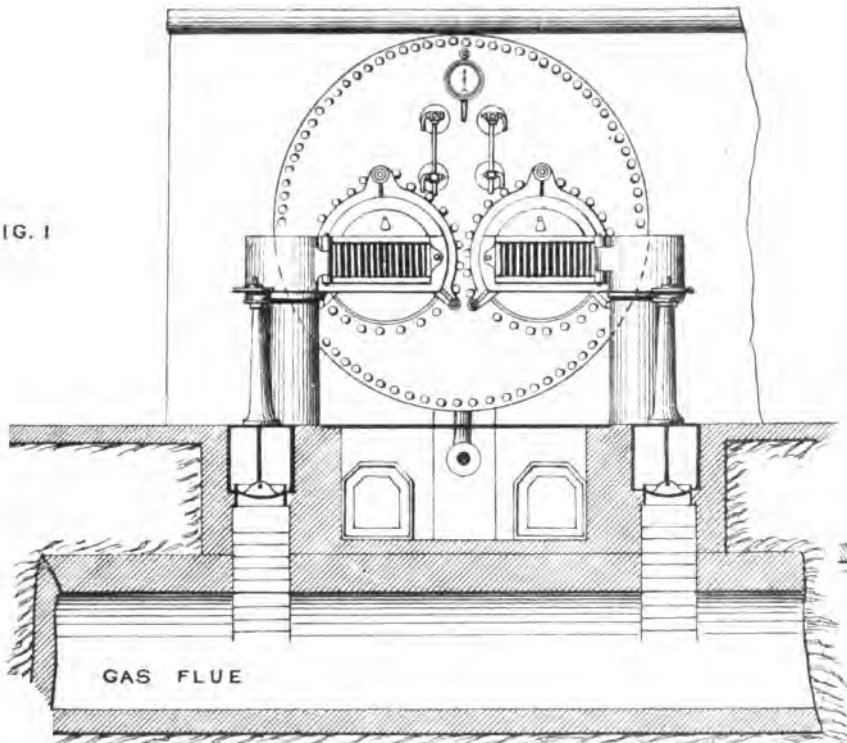


FIG. 2

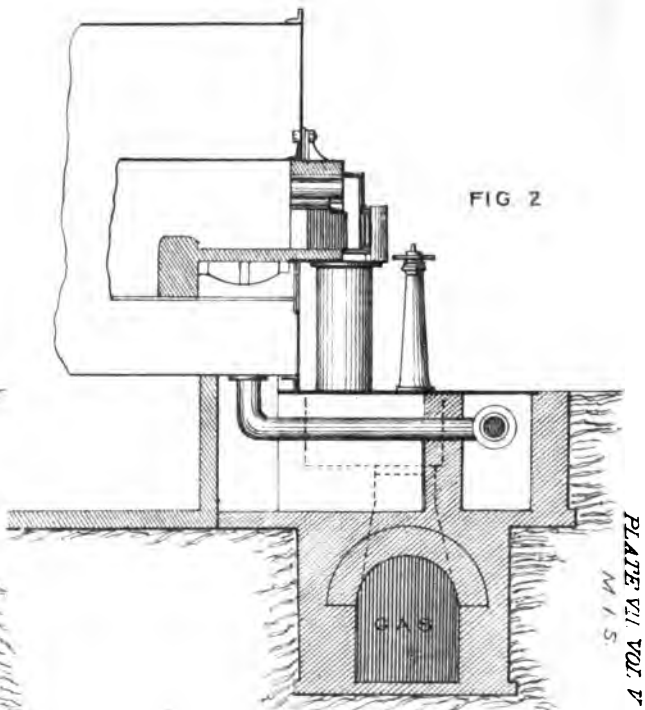


PLATE VII VOL 4
M I S

Recently, a very carefully conducted series of comparative trials of gas and hand firing has been made in this country by Mr J. H. Darby, engineer to the Plas Power Colliery at Wrexham, whose report I am enabled to quote in full. He employed two boilers of the Lancashire pattern of identical design and dimensions, one (illustrated on figs. 1 and 2) being fired by gas from a Wilson producer with the arrangement of furnaces, gas valves. &c., as shown in the figs., but without any elaborate arrangement of boiler setting as in the French experiments, and with the minimum of brickwork in the combustion arrangements. The other was fired by hand in the usual way. Measurements of the water and coal used, and analyses of all gases from the producer and in chimney flues* were made, and the *modus operandi* was slightly altered in the experiments in order to ascertain the best way of working. The result he has stated to be an average economy of 27 per cent. in favour of the gas fired boiler.

REPORT of Trials conducted at Plas Power Colliery of the Comparative Economy of Firing Boilers by Gas and Hand.

THE two boilers selected for the experiments were set side by side, and of the following size and dimensions :—Length, 27 feet ; diameter, 7 feet ; with internal flues of the Lancashire pattern, seven diagonal tubes being placed in each flue. Effective heating surface in each boiler, 443 sq. ft. No. 1 was heated by gas from a WILSON Producer. No. 2 was hand-fired by the usual method. The feed-water was supplied from 2 iron tanks by a pump :—

No. 1 tank supplying No. 1 boiler, measuring 15′ 11¼″ × 7′ 6″.
No. 2 tank supplying No. 2 boiler, measuring 15′ 11¼″ × 6′ 11¼″.
The gauge of the tanks was then :—No. 1, 581 lbs. water per inch depth. No. 2, 576 do.

The draught caused the burnt gases to pass first along the internal flues, then back along the bottom of the boiler, splitting at the front into a flue on each side, and along these to the main flue.

In trial No. 1, the hand-fired boiler was worked as is usual at the Colliery, with the damper open, and a draught of 16 to 20 millimètres (·6 to ·78 of an inch) of water, so as to burn the inferior fuel.

* NOTE.—Examinations of the waste gases from two boilers similarly fired by gas from Wilson producers at Messrs Tangye's Steel Works, Birmingham, have been made by Pattinson & Stead, who certify that the average of six analyses gave 13·20 per cent. of carbonic acid, precautions having been taken to remove sulphur dioxide before treating the gases with potash. This result shows a completeness of combustion equal to that shown by the analyses in Mr Darby's trials.

In trials No. 2 and 3, with the same boiler, the draught was regulated to 9 millimètres (3½ tenths of an inch), the fires being so worked that the red fuel was pushed forward towards the bridge, while the green fuel was being coked near the deadplate. There was, however, much trouble in burning the inferior fuel by this method of firing, the boiler taking the entire attention of one stoker.

Description of Coal used :—Refuse.

TRIAL No. 1.—Nos. 1 and 2 Boilers.

Duration of trial.....11 hours.
Draught.....16 to 20 millimètres ($\frac{6}{10}$ths to nearly $\frac{8}{10}$ths of an inch).
Pressure of steam.....50 lbs. per square inch.

No. 1 Boiler.—(Producer).

Used 8,260 lbs. of fuel.
„ 47,932 lbs. of water—4,357 lbs. per hour.
1 lb. of fuel evaporated 5·8 lbs. of water.
Fuel gave clinker and refuse 13·5%.
Temperature of water for feed, 40° centigrade (=104° F.).
Pressure of gas in Producer, 20 millimètres = nearly $\frac{8}{10}$ths of an inch.
Carbonic Acid in gases issuing from the end of internal flues, 8·2%.
Sample of gas from Producer gave on analysis :—

Carbonic Acid	7·14
Oxygen	0·00
Hydrogen	12·15
Carbonic Oxide	19·83
Marsh Gas	3·61
Nitrogen	57·24
	99·97%

Temperature in annular flue of Producer, 960° C. (=1760° F.).
„ above gas valve under boiler, 740° C. (=1364° F.).
„ in fuel of Producer, 1300° C. (=2372° F.).

No. 2 Boiler—(Hand-Fired).

Used 6,160 lbs. of fuel.
„ 32,616 lbs. of water—2,965 lbs. per hour.
1 lb. of fuel evaporated 5·3 lbs. of water.
Fuel gave 16·6% of clinker and refuse.
Temperature of feed-water, 40° C. (=104° F.).

In the foregoing trials, the fuel burnt as gas in No. 1 boiler gives a better duty by 9·4% than the same class of fuel burnt under No. 2 boiler by hand-firing, the duty done by each boiler per hour being in favour of the gas-fired boiler.

Gas-fired boiler, 4357 lbs. of water evaporated per hour.
Hand-fired „ 2965 „ „

With the temperature of the feed-water at 100° C. (= 212° Fahr.) and the steam at atmospheric pressure, the duty per lb. of fuel would be as calculated :—

No. 1 gas-fired boiler, 6·86 lbs. of water evaporated per lb. of fuel.
No. 2 hand-fired „ 6·26 „ „ „

Before making Trial No. 2, various tests were taken to ascertain what conditions of draught were most favourable to a high percentage of carbonic acid in the burnt gases.

TRIAL No. 2—Nos. 1 and 2 Boilers.

Description of Fuel :—Refuse from Screens.
Duration of trial.....9½ hours.
Draught.. .....9 millimètres of water (3½ tenths of an inch).
Pressure of steam.....50 lbs. per square inch.

No. 1 Boiler (Producer).

Used 6104 lbs. of fuel.
„ 39943 lbs of water—4204 lbs. per hour.
1 lb. of fuel evaporated 6·5 lbs. of water.
Fuel gave 12·6% per cent. of clinker and refuse.
Temperature of feed-water 30° C. (=86°F.)
Pressure of gas in Producer, about 20 millimètres (nearly $\frac{8}{10}$ths of an inch.)
Carbonic Acid Gas, in gases issuing from end of internal flues, ... 13·4%
With slightly redder flame, carbonic acid, ... 16·2%
Oxygen, ... 1·4%
Carbonic Oxide, ... ·8%
Temperature of gases in annular ring of Producer, 750° C. (=1382°F.)
„ „ valve below boiler, 570° C. (=1058°F.)
„ of waste gases in flue to chimney, 320° C. (=608°F.)
„ of air heated by waste gases before combustion, 120° C. (=248°F.)
In this Trial the level of the fuel in the Producer was about 4ft. from the ground.

No. 2 Boiler (Hand-Fired).

Used 4704 lbs. of fuel.
„ 29880 lbs. of water—3145 lbs. per hour.
1 lb. of fuel evaporated 6·3 lbs. of water.
Fuel gave 13·6 per cent. of clinker and refuse.
Temperature of feed-water, 30° C. (=86°F.)
Carbonic Acid in end of internal flues, ... 10·0%
Oxygen, ... 8·9%
With slightly redder flame—Carbonic Acid in end of internal flues, 14·2%
„ „ Oxygen, ... 4·6%

In No. 2 Trial, the fuel burnt as gas in No. 1 boiler gives a better duty by 3·2% than the same class of fuel burnt under No. 2 boiler by hand-

firing. But contrasting the duty done by No. 1 boiler during No. 2 Trial, with the duty done by No. 2 boiler in No. 1 Trial, there is a better duty given by No 1 boiler over No. 2 boiler of 22·6%. With the temperature of the feed-water at 100° C. (= 212 Fahr.), and the steam at atmospheric pressure, the duty per lb. of fuel would be as calculated :—

No. 1 boiler (gas-fired) 7·8 lbs. of water evaporated per lb. of fuel.
No. 2 boiler (hand-fired) 7·5 ,, ,,

The duty done by each boiler per hour is in favour of the gas-fired boiler, as under :—

Gas-fired boiler, 4204 lbs. of water evaporated per hour.
Hand-fired ,, 3145 ,, ,,

TRIAL No. 3.

It was resolved to try the fuel in the Producer at a higher level, in order if possible to reduce the temperature of the gases on leaving the Producer, and also to reduce the percentage of carbonic acid in the gases.

Nos. 1 and 2 Boilers.

Duration of trial.....9 hours.
Draught.....9 millimètres of water (=3½ tenths of an inch).
Pressure.....50 lb.
Description of fuel.....Best Coal.

No. 1 Boiler—(Producer).

Used 3948 lbs. of fuel.
,, 33916 lbs. of water—3768 lbs. per hour.
Fuel gave 12·5% of clinker and refuse.
Temperature of feed water, 30° C. (=86°F.)
Pressure of gas in Producer, about 22 millimètres (=8½ tenths of an inch).
Carbonic acid in gases issuing from end of internal flues, 14·0%
Oxygen ... ... 2·8%

An analysis of the gases, taken when the Producer seemed to be at its best, and a larger quantity of steam entering by steam jet, at a lower velocity than in the former trials, gave :—

Carbonic Acid, ...	4·11
Oxygen, ...	0·00
Hydrogen, ...	12·42
Carbonic Oxide, ...	26·48
Marsh Gas, ...	5·91
Nitrogen, ...	51.06
	99·98%

An analysis of the average of three samples, which may be taken as a fair average analysis of the gases, gave:—

Carbonic Acid	6·26
Oxygen	0·00
Hydrogen	14·68
Carbonic Oxide	23·98
Marsh Gas	4·72
Nitrogen	50·36
	100·00

Temperature in annular flue of Producer, 600° C. (=1112°F.)
" valve below boiler, 450° C. (=842°F.)
" of waste gases in flue to chimney, 290° C. (=554°F.)
" air heated by waste gases before combustion, about, 120° C. (=248°F.)

In No. 3 trial, the level of the fuel in the Producer was about 6 ft. from the ground.

No. 2 Boiler (Hand-Fired).

Used 3724 lbs. of fuel.
" 29520 lbs. of water—3280 lbs. per hour.
1 lb. of fuel evaporated 7·9 lbs. of water.
Fuel gave 11·6% of clinker and refuse.
Temperature of feed-water, 30° C. (=86° F.)

In No. 3 trial, the fuel burnt as gas in No. 1 boiler gives a better duty by 8·86% than the same class of fuel burnt under No. 2 boiler by hand-firing. With the temperature of the feed-water at 100° C. (=212° Fah.) and the steam at atmospheric pressure, the duty per lb. of fuel would be as calculated:—

No. 1 boiler (gas-fired) 10·33 lbs. of water evaporated per lb. of fuel.
No. 2 " (hand-fired) 9·49 " " "

	No. 1 Trial.			No. 2 Trial.			No. 3 Trial.		
	lbs. of water evaporated by 1 lb of fuel, feed-water at 100 deg. C., steam at atmospheric pressure.	lbs. of water evaporated by 1 lb. of fuel.	Water evaporated per hour in lbs.	lbs. of water evaporated by 1 lb of fuel, feed-water at 100 deg. C., steam at atmospheric pressure.	lbs. of water evaporated by 1 lb. of fuel.	Water evaporated per hour in lbs.	lbs. of water evaporated by 1 lb of fuel, feed-water at 100 deg. C., steam at atmospheric pressure.	lbs. of water evaporated by 1 lb. of fuel.	Water evaporated per hour in lbs.
No. 1 Boiler (gas)	6 86	5·8	4357	7·8	6·5	4204	10·33	8·6	3768
No. 2 Boiler.....	6·26	5·3	2965	7·5	6·3	3145	9·49	7·9	3280

In summing up the results of the foregoing tests, I must remark that the No. 1, or gas-fired boiler, was under considerable disadvantage through all the trials, owing to only one Producer being at work to supply it, the quantity and composition of the gases vary so much from one addition of fuel to another that it is almost impossible to regulate the supply of air for combustion to the adequate amount. If we had several Producers working together, the duty done by the fuel would have been better. On the other hand, I do not think that the hand-firing in the Nos. 2 and 3 trials could be improved, as the greatest care was taken.

With our bituminous coal, it does not answer to run the Producer as high as in trial No. 3. A large quantity of tar was formed in the flues and around the valves, and would have quickly obstructed the passage of the gas.

As regards labour costs in each method, if all our boilers (seven in number) were fired by gas, we should require six Producers of the 4 cwt. per hour size, one to be always off for cleaning, but this would generate more steam than we require. The gas-fired boiler making 32% more steam than the hand-fired boilers in a given time, or after deducting the steam used by the steam jet (to 170 lbs. of water per hour) gives 26·9% more duty. Therefore, I think that five Producers, four working and one off for cleaning, would make all the steam we require, and would take six men to work them. Six men are at present required to fire the seven boilers as in trial No. 1, but to fire them as in trials No. 2 and 3 it would require eight men.

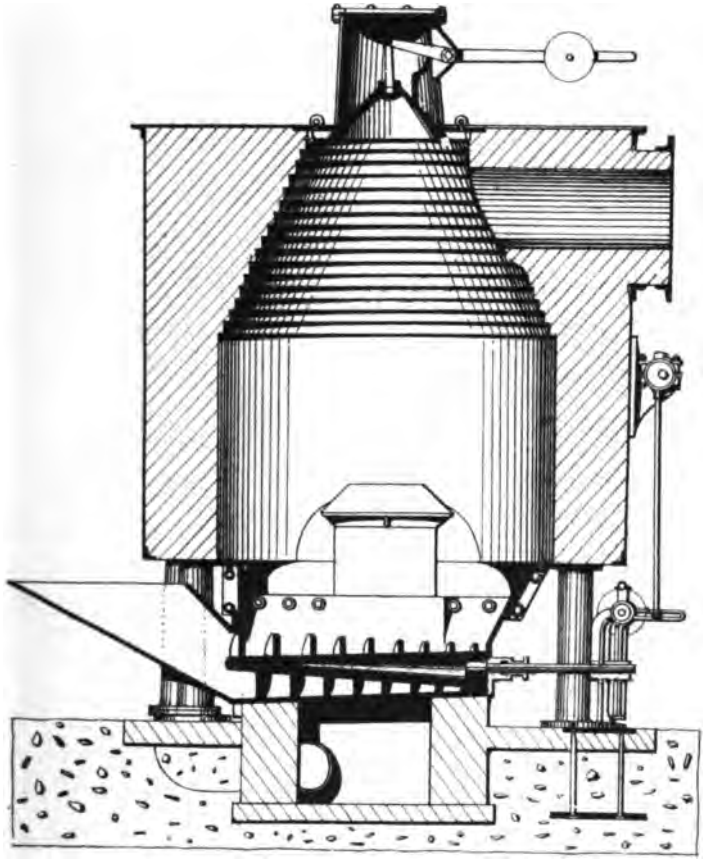
(Signed) JOHN H. DARBY,
Engineer to the Plas Power Colliery.

With reference to the concluding paragraph in this report it must be remarked that Mr Darby estimated the number of men required to work five gas producers by simply multiplying the labour required for one. This, however, is an erroneous estimate, for it is found in practice that four men are enough to work seven or eight such producers. This refers to the design of producer illustrated in the author's paper to this Institute on "Gas Firing" (*Transactions*, vol. iii, part 7, 13th Oct., 1881), which requires to be cleaned out periodically by hand labour. The new design, which has recently been worked out, removes the necessity for this labour by the introduction of mechanical appliances for automatically cleaning out the ash and clinker from the producers continually. This design of producer is illustrated in figs. 3, 4, and 5; figs 3 and 4 being vertical sections at right angles to one another, and fig. 5 showing a section representing

THE WILSON AUTOMATIC CLEANING GAS PRODUCER.

SECTIONAL ELEVATION.

FIG. 3.

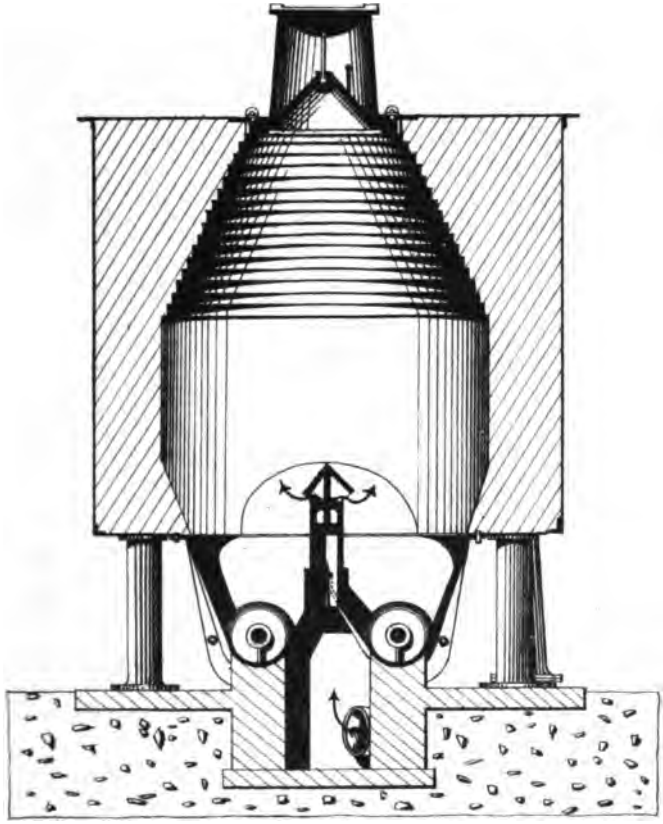


To illustrate Mr Rowan's Paper on "Gas Firing for Steam Boilers."

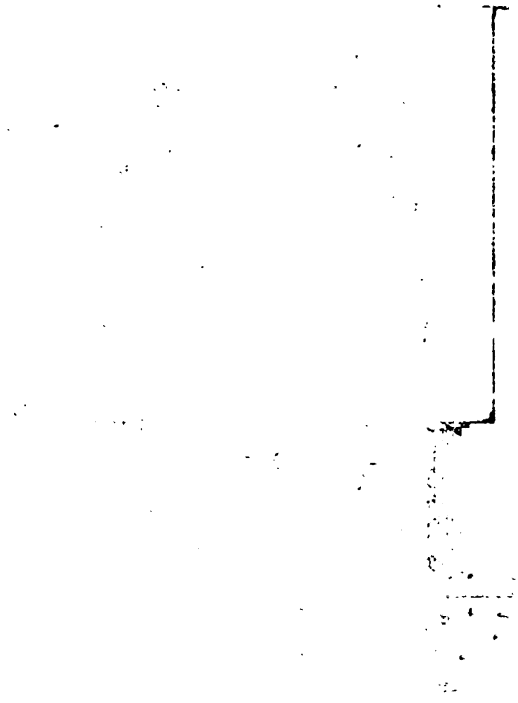
THE WILSON AUTOMATIC CLEANING GAS PRODUCER.

SECTIONAL ELEVATION AT RIGHT ANGLES TO FIG 3

FIG. 4.



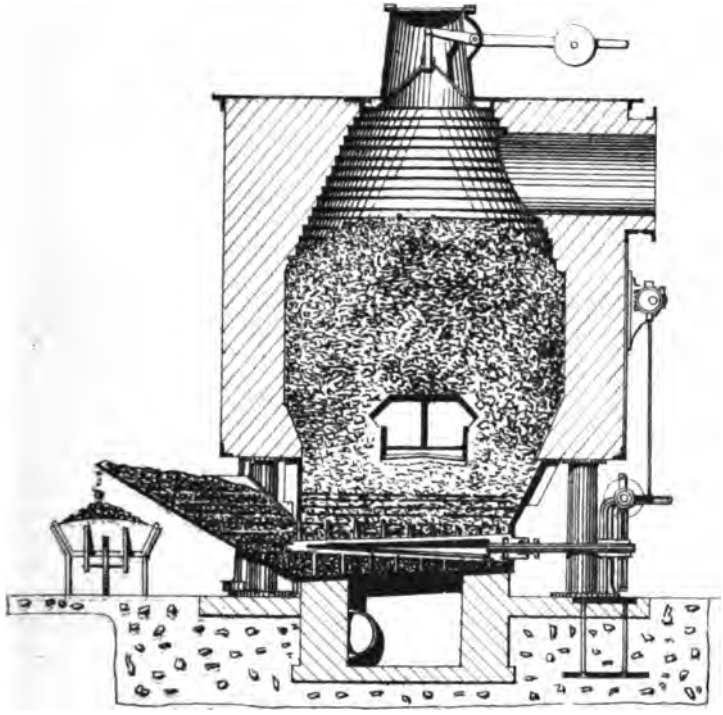
To illustrate Mr. Rowan's Paper on "Gas Firing for Steam Boilers."



THE WILSON AUTOMATIC CLEANING GAS PRODUCER.

SECTIONAL ELEVATION SHOWING PRODUCER AS WHEN WORKING.

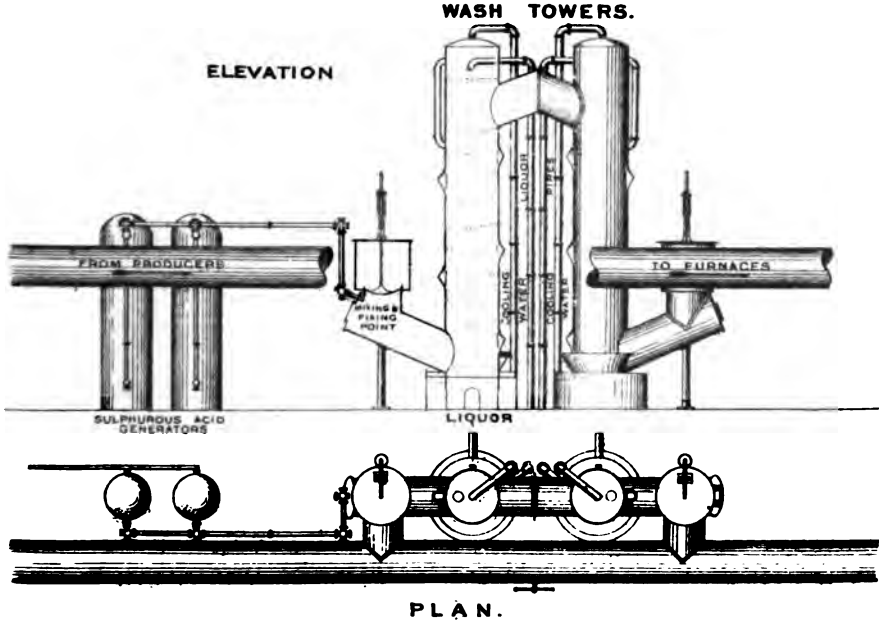
FIG. 5.



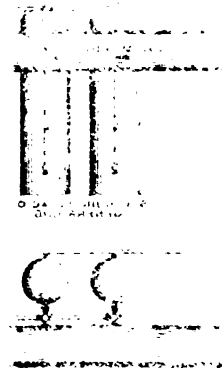
To illustrate Mr Rowan's Paper on "Gas Firing for Steam Boilers."

PLANT FOR RECOVERY OF AMMONIA FROM GASES BY ADDIE'S PATENT PROCESS.

FIG. 6.



To illustrate Mr. Rowan's Paper on "Gas Firing for Steam Boilers."



the producer as in actual operation, charged with dross, and the discharging worms in the act of propelling the refuse upwards, through the iron spout, out of which it falls on to a barrow placed to receive the discharge.

The two discharging worms work in a cast iron trough filled with water which acts in several ways. It, of course, prevents the worms and bottom of the producer being burnt, it cools the ash and clinker falling down from the zone of combustion, and thus acts as a recuperator of heat, because the heat which is usually lost in withdrawing ash and clinker at a full red heat is retained in this producer, the refuse passing out at a temperature not over 150° Fah. The steam rising from the water in the trough keeps the central tuyere or nozzle from being burned, and the steam itself is decomposed by the glowing carbon and adds hydrogen and carbonic oxide to the producer gas. The producer works continuously at its maximum speed with the minimum of labour.

The paper recently read by Mr Beilby to this Institute has shown an addition to the use of gaseous fuel which is now assuming an increasing importance, viz., the recovery of the ammonia and tar products from coal. And as it is probable that boiler firing by gas on even a moderate scale will not in the future be carried out without the addition of such means of deriving profit from the use of coal as fuel, fig. 6 is added, showing the arrangement of plant patented and carried out by Messrs Addie & Sons at Langloan Iron Works for the recovery of ammonia and tar from blast furnace or producer gases and applied by us to producer gas.

In working this plant sulphurous acid gas is produced from some cheap source of sulphur burned with air in suitable chambers, and this sulphurous acid is mixed with the producer gas while hot, before it enters the scrubbing towers shown. The ammonia in the gas is fixed by combination with the sulphurous acid, and a very moderate amount of scrubbing and of cooling the gases subsequently is found sufficient to remove every trace of ammonia from the escaping gas.

This plant is comparatively inexpensive and is found to be very successful, the patentees recovering 30 to 35 lbs. sulphate of ammonia, of first rate quality, per ton of coal from blast furnace

gases. From the fact that in the Wilson gas producer, combustion is carried on in an atmosphere of steam, it is probable that a much larger quantity of ammonia will in it be produced from the nitrogen of the coal.

The CHAIRMAN intimated that this paper would be discussed at next meeting.

ON THE VALUATION OF IRONWORKS, MINES, &c., BY DAVID COWAN, C.E., CARRON IRONWORKS, MANAGER FOR CARRON COMPANY.

The valuation of these subjects forms one of the most important duties of the Mining Engineer, who, to deal with the matter properly, should not only be a scientific man, but a financier as well.

The principles on which such valuations are conducted are not so well understood as they might be; as it is an undeniable fact that capitalists are frequently misled as to the value of these subjects. The writer takes this opportunity of bringing the matter before the Institute, chiefly with the object of affording an opportunity for discussing the principles on which such valuations should be conducted.

The best measure of the value of any subject is the amount of profits to be got out of it annually; and these treated as terminable annuities to be bought and sold on fair terms, should form the leading principle of such valuations.

In estimating future annual profits, a complete retrospect of the costs and prices realised for the various products is most necessary. A review of the trading profits extending over a series of years is also of the utmost importance, as a guide to correct calculations.

By such light as can be gleaned from the operations of the past, and a careful study of the probabilities of the future, the profits and values to be given effect to in the valuation are arrived at. In estimating future profits, consideration must be

given to the prospects of trade, and a careful calculation made of the probable future costs, having regard to the influencing circumstances; and in order to do so it may be necessary for the valuator to confer with the most eminent Engineers, Ironmasters, and Merchants in the district and elsewhere.

Smelting Ironworks depend so much on mines connected with them, that the business must be viewed more in the light of a mining than of a manufacturing concern; and as mining operations are not free from risk, purchasers of mines require, and are entitled to a rate of interest on the purchase money corresponding to the degree of risk; and where the annual profits and annuities are terminable the purchase money must also be recouped to the purchaser at the end of the profit-making period.

In such cases as where the annuities are perpetuities, of course no provision requires to be made for recouping the purchase money.

No rule can be laid down for calculating the attendant risk of mining adventures; as nearly all mines exist under circumstances differing widely from each other. Each concern must stand on its own merits; and the amount of percentage or rate of interest allowed must be varied according to the circumstances of each particular case. Mines are valued at rates ranging from 8 to 20 or 25%. In going concerns, under ordinary circumstances, the rates of interest allowed range from 10 to 15% on the purchase money, besides an allowance at a lower rate of interest, say 3 to 5%, for recouping the purchase money.

These general principles may best be understood by an example. The illustrations proposed to be given are taken from valuations of wide range, which have come within the scope of the writer's own practice.

It is presumed that a careful and exhaustive review of the mineral resources of the concern has been made, and that the connection between the mines and the ironworks has been shewn. It is further assumed that the minerals have been delivered to the latter at the net cost prices. We now proceed to consider the capabilities and values of the iron-smelting plant and the mineral resources in the manner following.

SECTION A.

In this example it is assumed that the SMELTING WORKS are erected on LEASEHOLD LAND, with 85 years of the lease to run, and that the blast furnaces are 11 in number, 9 of which are completely equipped in every respect and 2 in course of erection.

It is considered that out of the 11 furnaces there would generally be one out of blast for repair, and that on an average of future years the probable annual production of pig-iron from these works would be 100,000 tons; and the probable average profit over the first 15 years (during which period the minerals would be cheaper got than they would be afterwards) is estimated at 7s per ton, which gives an annual profit of £35,000.

In the 27 years immediately succeeding, the cost of producing pig-iron would be greater, from the increased cost of the raw material; and consequently the profit could not be put higher than, say, 5s 9d per ton. This profit, with an annual production of 100,000 tons, is equal to an annual income of £28,750.

At the end of the second period, or 42 years hence, the minerals in the leasehold lands would be exhausted; and, as the supplies for the furnaces during the remaining 43 years of the lease must be obtained in the open market, the annual profit during that period is estimated at 4s per ton, which on 100,000 tons gives an annual profit of £20,000.

The income from the works may be stated shortly, thus—

First 15 years, . . .	£35,000	per annum.
Next 27 „ . . .	28,750	„
Next 43 „ . . .	20,000	„

In valuing these annuities, the aim of the valuation should be to put such a value on them as would not only yield a purchaser a fair return for the money invested, but would also cover the risk individual to all such works and businesses; and this is estimated at 15 % on the works. In addition to this, a small sum should be set aside out of the annuities annually to accumulate at 4 % per annum, so that at the termination of each of the successive periods into which the term of the lease is divided the purchasers may have in hand a sum equivalent to the difference in value of the annuities belonging to the different periods.

Thus, the annuity for the first period of fifteen years is £35,000; and for the second period, £28,750; being a difference of £6250 per annum; and as the annuity ceases at the end of fifteen years, it is necessary that the purchasers should thus have the difference in value returned, otherwise the capital would be lost. So, in like manner, at the end of the second period the annual income is again decreased by £8750, that being the annual difference between the annuities in the second and third periods; and the purchase money of this sum must be recovered 42 years hence. The purchase money of the annuity of £20,000 in the last period must all be recovered 85 years hence, as the lease and profits then cease.

The value of these several annuities is as follows:—

£20,000 per annum for 85 years, allowing 15 per cent. per annum, (the purchase money being returned,) is worth 6·601571 years' purchase, or . .	£132,031
£8750 per annum for 42 years on the same conditions is worth 6·268013 years' purchase, or .	54,845
£6250 per annum for 15 years on the same conditions is worth 5·001471 years' purchase, or .	31,259
Total value of these three annuities, .	£218,135
As the entire plant is essential for the production of the profits, it falls to be valued only as available for sale at the end of the lease. It is then worth, at its auction value, (which is assumed as having been made up from a detailed inventory,) £45,595. The present value of this sum 85 years hence, allowing a purchaser 4 per cent. per annum, is 0·357 years' purchase, or	1,628
Total gross value of Section A, . .	£219,763

The stocks of materials and other incidents are added after the valuation of all the subjects. At the same time, effect is given to the deductions for outlays necessary to complete the works; and for maintaining them in a condition to earn the profits above estimated.

SECTION B.

Another section of the SMELTING WORKS is assumed as situated on FREEHOLD PROPERTY, and which of course falls to be dealt with as a perpetuity in the manner following.

After describing the works and ascertaining their capabilities, annuities are arrived at in a manner similar to that above described for the A section, or leasehold portion of the works, the only difference between the two sets of annuities being, that in the case of the leasehold works the annuity for the last period is terminable. In the case of the freehold works the annuity during the last period is perpetual.

The amounts arrived at, as above explained, are assumed as equivalent to—

£9,200	per annum	in perpetuity.
2,875	„	for 42 years.
2,875	„	for 15 years.
£14,950,	income	during first 15 years.

These are valued as follows :—

£9200 per annum at 15 per cent. in perpetuity is worth 6·066666 years' purchase, or . .	£61,333
£2875 per annum for 42 years, with capital returned at 4 per cent., is worth 6·268013 years' purchase, or	18,020
£2875 per annum for 15 years, with capital returned, is worth 5·001417 years' purchase, or .	14,379
Total gross value of Section B, . .	£93,732

In this case it will be observed that no value is attached to the plant. The plant being essential towards the earning of the perpetual annuity, materials and stocks are, as in the case of Section A, added at the summary of the valuation.

SECTION C

We will suppose to consist of BAR-IRON or STEEL WORKS, situated on FREEHOLD LAND, completely equipped with apparatus of every kind for turning out annually 38,000 tons.

The average profit after examining the cost sheets, returns of sales, trading accounts, etc., is for the future estimated to average 10s per ton, and this on 38,000 tons gives an annuity of £19,000 in perpetuity. Allowing a purchaser 15 per cent., the present value is worth 6.666666 years' purchase, or £126,667, which is total gross value of Section C.

Materials and stocks, as in Sections A and B, are given effect to in the summary of the valuation.

In connection with such concerns as are now under consideration, there are many other subjects to be dealt with: such as FOUNDRIES, FIRE-CLAY and BRICK WORKS; OIL WORKS, and SALE COLLIERIES; but these all fall to be dealt with much in the same manner as those already touched on; the modifications necessary to suit the peculiar conditions of each being subject to the skill and judgment of the engineer. For the present purposes further examples do not seem necessary.

The following is a recapitulation of the gross valuation of the foregoing annuities, which are those arising purely from manufacturing profits :—

Section A, gross value, ...	£219,763
„ B, „	93,732
„ C, „	126,667
Total, .	£440,162

The sum includes the value of all the IRONSTONE MINES, COLLIERIES, and LIMESTONE QUARRIES necessary for supplying the smelting furnaces during the periods herein dealt with, as also the auction value of the furnace plant on the leasehold land; but in addition to this there is the auction value of the mining plant, 42 years hence, to be added, Assuming the auction value to be £45,117, the value of this sum 42 years hence, allowing the purchaser 4 per cent., is worth 0·1926 years' purchase, or . . 8,690

Thus the total gross value of the Mines and Works and all necessary plant and land on which works are placed is £448,852

It often occurs that there are other subjects differing in their nature from those yielding the foregoing values or annuities, and which also are purely derived from manufacturing profits. These other subjects likewise fall to be dealt with in arriving at the value of such concerns as are now under consideration. The following are some of the more common examples :—

I. SHORTS.—It often happens under mineral leases that periods are allowed for the making up of "shorts," *i.e.* shortcomings of output to meet the fixed rent. In Scotland these periods seldom exceed a few years. In England the periods are often much longer. For present purposes we will assume that the shorts amount to £11,333 ; and that the reduction of them will extend over 10 years, or an annuity during that period of £1,133 6s. Assuming the mine to be properly opened, and the minerals sufficient to meet all requirements, it is clear that the risk in the profit arising from this annuity is not so great as that attending the annuity arising from an undeveloped property. The purchaser should therefore look for a lesser percentage on his purchase money.

The annuities from the manufacturing profits were valued at 15% (capital returned) ; but 8% should be sufficient to meet this case. £1,133 6s for 10 years discounted at 8%, and allowing a sum to be set aside annually which accumulating at 4% should at the end of 10 years amount to the purchase price, is worth 6·1240 years' purchase, or £6,940

II. SUBLEASE.—A portion of a mineral field may be subleased. Assuming the premium rental to be £100 for 13 years, the value to a purchaser, allowing 8% (capital to be returned) would be worth 7·1356 years' purchase, or 714

III. MINERS' HOUSES.—In the case of a rental being charged for such houses, and which rental is included in the cost of the minerals, the capitalization of this rental falls to be added to the valuation of the subject.

Under Section A it was assumed that the duration

of the mines would be 42 years. Assuming the net rental of the workmen's houses, after all necessary deductions, to be £1072 per annum, this sum is treated as an annuity for 42 years. If the purchaser is allowed 8 per cent. on the purchase money, (and the capital returned,) the present value is worth 11·1682 years' purchase, or £11,972

IV. MINERS' HOUSES UPON WHICH NO RENTALS HAVE BEEN CHARGED TO THE COST ACCOUNT.—Assume the value of the houses and of the land on which they are built to be £1,737.

After the mines are worked out, (42 years hence; see Section A,) this house property should still be available for earning profits.

The present value of £1,737 deferred for 42 years at 8 per cent. is worth 0·0395 year's purchase, or . 69

V. FREEHOLD LAND NOT REQUIRED FOR THE PURPOSES OF THE WORKS AND AVAILABLE FOR IMMEDIATE SALE should be put down at its current value for the time being. Assume this to be . 100

VI. WAYLEAVES.—It may happen that a Wayleave has been granted to a neighbouring concern; the value of this is determined by the duration and the average annual rental received.

Assume the annual rental to be £45 and the duration 22½ years, and 7% to be sufficient to cover the risk: £45 per annum for 22½ years discounted at 7%, and capital returned at 4%, is worth 10·181 years' purchase, or 458

Total value of miscellaneous subjects, . . £20,253

Total gross value of mines and works, brought forward, ... 448,852

Add to this the value of STOCKS and STORES, which should be valued at their current value. Assume this to be 30,895

Total gross value, ... £500,000

DEDUCTIONS.

Such valuations proceed upon the assumption that the Mines, Collieries, and Ironworks are in a position to produce the estimated revenues; but where such is not the fact a sum must be deducted which, in the judgment of the valuator, is necessary to place the properties in the required state of efficiency. These deductions may take the following form:—

I. To complete the two Blast Furnaces assumed in Section A as in course of erection, an immediate outlay is required of £5,000

II. To complete an Ironstone Pit with the necessary plant and make all the necessary openings to command the requisite tonnage, with the outlay upon branch railways to join the main line, a sum of £12,000 is required, to be spent during the next four years. This gives an average annual payment of £3000, the present value of which, discounted at 5 per cent. (capital returned), is worth 3·5027 years' purchase, or 10,508

III. It may so happen that, say, ten years hence, an outlay of, say, £20,000, is required in order to maintain the requisite output of coal; and that this outlay should be divided over a series of years, say five. Thus we have an annuity of £4000 for five years, but deferred for ten years; the present value of which, allowing the purchaser 5 per cent. interest and redemption of capital at 3 per cent., is worth 2·5756 years' purchase, or 10,302

IV. In connection with such concerns there are many covenants to be fulfilled, such as, fines on renewal of leases, restoration of damaged ground, etc. The expenses connected therewith must necessarily be speculative. It will be necessary to set aside an annual sum to form an ample reserve fund to meet such. Assuming that in the judgment of the valuator £1000 per annum is ample, the present value of the

annuity in perpetuity, allowing interest at 4 per cent., is worth 25 years' purchase, or . . . 25,000

Total amount of deductions to be made, . . £50,810

The gross sum at which the whole concern was valued is £500,000; less deductions as above, £50,810, leaving the net sum, £449,190, as the value of the whole subjects.

The foregoing examples, although stated very briefly, will be seen to embrace a very wide range of subjects. To deal with such a concern successfully requires real skill, combined with honesty of purpose. Upon the application of these to the operations of mining the whole success of the undertaking depends.

Thus it will be seen that mining operations offer a field for the highest talent, as well as for more moderate attainments; and it is to be hoped that mining proprietors and investors will see it to be their interests to intrust their capital only into the hands of men who should well understand the position they are to occupy; and that the persons so trusted should see it their duty rather to make some sacrifice than deviate from a course strictly honourable.

The CHAIRMAN intimated that the discussion of this paper would be taken up at next meeting. The proceedings then terminated.

NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES.

TRANSACTIONS of the AMERICAN SOCIETY of CIVIL ENGINEERS, vol. xii., No. cclxi., August, 1883.—"ON THE CURRENT METER; together with a reason why the maximum velocity of water through open channels is below the surface." Under the above heading, an account is given of observations made in measuring the flow of water in the conduit conveying water to Boston from the Sudbury river. The instruments used were a wheel with ten vanes and another similar, but with eight vanes, somewhat after the style of our anemometer, and having gearing to register the revolutions of dials attached. The instruments were first carefully rated by recording revolutions at different speeds, as they were drawn at a uniform rate through still water. When in use, a brass rod of sufficient length was fastened to each as a handle. Observations were taken at various depths and at different distances across the conduit; so as to ascertain the mean flow, as well as to note any peculiarities in the current. The experiments seem to have been conducted with great care; and every possible correction was made so as to eliminate any error. As was to be expected, the flow at the sides and bottom was slower than at the centre; but a fact more recently noticed was clearly established, viz., that the maximum velocity was not at the surface unless in shallow depths. The conduit is about 9 feet wide, and with a mean velocity of from about 3 feet per second with the greater quantity, to 2 feet per second with the smaller quantity of water. The maximum velocity was found as follows:—When the depth of water in the conduit was 4·5 feet, the maximum velocity was 1·3 below the surface; when 4 feet, at 1·3; when 3 feet, at 8 inches. At lesser depths it was found at the surface. The writer of the article also holds the theory, based on experiment and observation, that there is at the sides of channels an upward flow, which in the surface developes into a transverse flow to the centre of the stream, and thus retards the surface velocity. This movement depends on the roughness of the sides of the channel, and on its comparative width to depth; as in a wide channel, such as a river or broad canal, the maximum velocity has always been found at the surface. The principal point of interest and of value (though not altogether new) seems to be, that it is necessary, in estimating the flow of water in a confined channel, not to trust to any surface velocity to give the mean velocity; but to test the flow beneath the surface as well. Whether the roughness of the sides and bottom of any channel is in itself sufficient to account for these facts, or whether there is any inherent property of water tending in the same direction, has not yet been made clear; but the former seems practically a sufficient reason; as the smoother the surfaces are the steadier and more regular the flow will become; and very slight roughness is capable of setting up a considerable amount of transverse or other motion in such a mobile fluid as water. R. S.

A NEW METHOD for the DETERMINATION of NITROGEN in all its combinations, By Dr. H. Grouven; translated from the German by George Beilby.—This method for the determination of nitrogen in organic bodies is based on the principle that when a current of steam is brought in contact with carbon, and the temperature at the point of action is maintained at not less than 500° C., a decomposition of steam by means of carbon, or a gasification of carbon by means of steam takes place; in fact, that the carbon burns. If this action be carried out with the admission of a sufficient excess of steam, the oxygen of the decomposed steam combines with the carbon to form carbonic acid and carbonic oxide, while its hydrogen is set free. Further, when with the carbon nitrogen is present, the latter, in a nascent state, meets with nascent hydrogen: a position only requiring an excess of hydrogen to nitrogen, as 3 to 1, for the formation of ammonia. During the operation a large excess of steam is necessary to shield the newly formed ammonia from decomposition by the heat present. For a description of the apparatus employed in explanation of the features essential to the success of the process, readers are referred to the original pamphlet. On Dr. Grouven's showing, the process seems to admit of gratifying accuracy and of rapid manipulation. To the former of these results the "soda-lime process" has a somewhat dubious claim, and to the latter none. While this process has the merit of being applicable to the extraction of ammonia on a commercial scale, it offers advantages for the simple determination of nitrogen in foods and manures. Dr. Grouven's views may be read with great interest in conjunction with the valuable paper lately communicated to the Institute by Mr Beilby. J. H. R.

In the TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS for July, there is a paper by Professor Egleston on AN ACCIDENT to STEAM PIPES arising from the use of BLAST FURNACE WOOL, a substance now largely used as a non-conductor of heat. Sheathed pipes, used for heating purposes, packed with this mineral wool, burst on becoming leaky. The effect of the resulting moisture was to "sagg" the wool to the bottom of the sheathing, and also to form sulphuric acid with the sulphur (part of which is soluble) contained in the slag, which greatly intensifies corrosion. From the experiments of the Professor it appears that slightly moist air had no effect on the wool; but very dilute solutions of organic acids and alkalies dissolved out two or three times the quantity of sulphur that pure water did; and on this account he thinks it is not a very safe material for pipes laid under-ground, and suggests that the wool should be made from slags containing not more than a trace of sulphur.

There is also an able paper on GEODETIC FIELD WORK by Mr George Wisner, in which the methods for eliminating instrumental, observational, and even personal errors from the very exact figures necessary for the determination of longitude, latitude, and the triangulation of extensive surveys are clearly described. In the section dealing with the determination of astronomical azimuth he remarks, "That to establish a meridian line accurately enough for determining the variation of the magnetic needle is so simple a matter that it should be required by law of every county surveyor." The method of determining the exact length of base lines is also described.

Proceedings of the SOUTH WALES INSTITUTE of Engineers for July (vol. xiii., No. 5).—The discussion on the ENDLESS ROPE HAULAGE at Cymmer Colliery is resumed, the members taking great interest in that very important point in colliery haulage—the life of ropes. Mention is made that at a colliery in Nottinghamshire, in a system of endless rope haulage, the rope was driven by a steel faced capstan-drum, some 4 feet in diameter, of the same shape as a ship's capstan, round which the rope was coiled two or three times and continually "fleeted" from the larger to the smaller

diameter. It had worked satisfactorily and had extended the life of the ropes to five years, a statement which some of the members appeared to doubt. Notice is also taken of the fact that ropes which fail apparently without reason, when running with their usual load are likely to have been previously overstrained by tubs getting off the rails. Clip pulleys do not appear to be in favour in South Wales.

A paper on the ELECTRICAL TRANSMISSION of POWER at Trafalgar Collieries by Mr W. Brain, contains a description of experiments leading to the adaptation of an electro-motor for pumping water. The engine and generator are on the surface, and the electro-motor (weighing a little over two cwts., and capable of giving 4 H.P.) and pump are in the workings 600 yards from the generators. The pump is double-acting, throwing a gallon per stroke, but against what head does not appear; it may be driven from 60 to 70 strokes per minute, and has been working constantly since December last. It is connected to the engine on the surface by signal and telephone, so that the engineman can ascertain how it is working. The cost of one generator, motor, cable, and pump is given at £254 10s. The author contemplates the application of electric motors to more extensive pumping arrangements and also to winding, at these works; and he considers from their small weight in proportion to power, and the flexibility of the cable, that they are well adapted for working coal cutting machinery and rock drills.

Section D of Mr S. Walker's paper on the PRINCIPLES of ELECTRIC LIGHTING and TRANSMISSION of POWER by ELECTRICITY deals with the Transmission and Distribution of Power. He looks forward to the time when motive power will be distributed through a colliery by electricity from a large generator, pretty much as it is at the present day distributed through large works from a hydraulic accumulator. He gives examples of the measurement of the power and efficiency of different dynamos. Electric-motors, he says, from what had been found at the Marquis of Lothian's Collieries, would not work under water, and not for long in damp places. The Portrush Electric Engines are given as an example of movable motors, and a modification of the same plan, which is adopted in the Zankerode Mines in Prussia, is to have two copper wires overhead. A rod attached to the engine on each side carries a copper roller which makes electrical connection by resting on the rope. The methods of regulating direction and speed in such motors are also described.

Mr W. D. Wight in a paper on INJECTORS and other applications of Nozzles, treats a subject not well understood in a practical fashion without introducing any more algebra than $v^2 = 2gs$. Giffard's Injector and the Exhaust Injector, and also Morton's Ejector Condenser are described by the aid of sections and their action clearly indicated. Körting's Blower, an appliance in favour for giving forced draught to marine boilers, is also described by the aid of a diagram. Steam jets were not successful as colliery ventilators; but compared with this blower, the best of them were rude, and the author gives figures to shew that the cost of ventilation by means of these blowers should not be greatly in excess of the cost by the Guibal fan. J. G.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

INSTANTANEOUS OUTBURSTS OF INFLAMMABLE GAS IN THE COAL MINES OF THE BELGIAN BASIN.—A Paper of four chapters has been written by A. G. Arnould, Royal Chief Engineer of Mines at Mons; and the first of these chapters, which purports to give "a theoretical explanation of the formation of inflammable gas and its existence in the Belgian Mines," has been translated for this Institute by T. Mitchell. The author has been industrious in collecting information, and the grouping together of the facts and figures has resulted in a paper which is not without interest.

In the discussion on Mr Teale's Paper on "SAFE LIGHTING OF MINES" it was shewn that the mere fact of a lamp having gone out, under the conditions produced by an outburst of gas, is no proof that it is a safe lamp; because the conditions might be such that no lamp, not even a naked one, would have lived in it. Much must always depend on the proportions of air and gas; and, on occasion of such outbursts, every one is too much concerned in securing his own or others' safety to have time or inclination to test the condition of the atmosphere. It follows then, that nothing can be learned as to the relative safety of lamps from their behaviour on occasions of outbursts of gas, as a very indifferent safety lamp might be extinguished by an outburst if the gas was in overpowering quantities, and a very good safety lamp might explode with disastrous consequences if the outburst happened to be such as produced the requisite proportions for the most explosive mixture. J. D.

PROCEEDINGS OF THE PHILOSOPHICAL SOCIETY OF GLASGOW.

Volume XIV.

ARCHITECTURAL SECTION.

Dr. Wallace on DECAY of BUILDING STONES. -The appearance of ancient edifices, and many modern buildings in our large cities, speaks of the varied qualities of building stone in relation to weathering; and it is to the consideration of the conditions and causes which contribute to this weathering, with suggestions as to its prevention, that Dr. Wallace devotes his paper. Climatic conditions enter into the question; but it is more particularly a chemical one, and the author can speak with an authority which commands attention. The paper deals only with sandstone as a building material, twelve specimens of which were selected from well-known quarries and subjected to exhaustive tests as to chemical composition and physical properties. The results are given in a table. The binding material which cements the particles of silica into a sandstone—generally carbonates of lime or magnesia—is the source of weakness in withstanding the weather. These carbonates while insoluble in pure water, are readily dissolved by carbonic acid, which is invariably present to a greater or less amount even in rain water. To this in cities is added sulphuric acid, derived from sulphur in coal. The rain falling on horizontal projections on buildings sinks into the stone and removes the binding carbonates, leaving the loose particles to fall away. The suggestion to meet this is to avoid horizontal surfaces, and where unavoidable, to partially fill in the angle with Portland cement so as to make a steeper slope; or, where this is objectionable, to coat the stone with a strong solution of water-glass or silicate of soda. Perpendicular surfaces are not affected to the same extent as horizontal ones, and their protection is unnecessary, except with particularly bad sandstone. A preparation called "Alexinoton or Damp Repeller" is recommended when a change in colour or general appearance of a building is to be avoided. The paper is closed by an injunction against coating a building with any impervious substance before ample time has been allowed for the escape of moisture from the walls.

CHEMICAL SECTION.

Notes on NITRO-GLYCERINE, DYNAMITE, and BLASTING GELATINE, by George M'Roberts, F.C.S.—Recent inventions of new explosive compounds introduced an element of danger into the process of blasting, unknown in the days when gunpowder was the

only explosive used, inasmuch as the conditions under which these new explosives will explode, are more diverse and less accurately known. It is to a consideration of these conditions of explosion that the above paper is principally devoted; and it cannot fail to give much useful information to those using these explosive compounds, and also to correct many erroneous popular notions on the point.

Beginning with a description of the process of manufacturing NITRO-GLYCERINE, of its physical properties and chemical compositions, the author goes on to notice the several precautions adopted to secure safety in transit on its first introduction and before the invention of dynamite practically superseded it. It was conveyed n cases containing about 40 lbs., and the fall of one of these, even from the height of a few feet, almost always resulted in an explosion. Mr Nobel says—"A tin cartridge filled with nitro-glycerine causes no explosion if it drops from a height of several hundred feet on soft ground; yet that same cartridge falling only three feet on an anvil, bottom foremost, is sure to set the charge off, though there is not a particle of the explosive on the outside. Nitro-glycerine contained in a wooden barrel, headed with wood, would be as safe against all ordinary concussion as if it were common oil; the only danger could spring from leakage, which might expose it to a direct blow, but even that must be uncommonly strong to become dangerous, unless by two hard, sonorous bodies striking against one another." Many explosions in course of transit caused nitro-glycerine, as an article of commerce, to be finally excluded from Britain by Act of Parliament in 1869. If spread out in thin layers on an unyielding metalic surface nitro-glycerine is more explosive than even fulminate of mercury; and, contrary to popular belief, it is less liable to explosion when crystallized than when in liquid form. Solid, the author had seen it dashed to pieces against an iron plate without explosion; and miners have been known to break up frozen blocks of it with a pick. Indeed, in America, where it is still looked upon with favour, it is habitually frozen at the factory for greater safety in transit. Thrown on a hot plate, its behaviour depends on the temperature of the metal. If the plate be at a lower temperature than redness, the nitro-glycerine lies for a short time and then explodes; if the plate is a little hotter the explosive goes off in red fumes, and at red heat burns quietly away.

DYNAMITE may be described as nitro-glycerine absorbed in porous substances which may be explosive or non-explosive. Dynamite may be set on fire and burned without explosion; but if the quantity is very large, the unconsumed mass is gradually heated till the explosive temperature is reached, when it instantly goes off. When frozen, it is much less safe to treat it in this way; but a rifle bullet may be fired into it in that condition without explosion. Unfrozen, a rifle or pistol bullet fired into it, whether in packing-case or spread out loosely, causes an explosion. Thus, frozen dynamite is safer than unfrozen, as far as facility of explosion is concerned. Care is required in thawing frozen dynamite, as placing it on steam pipes or near a fire frequently produces an explosion before it is completely thawed; but it may be safely thawed in a water oven with the water at a temperature of 80 degs. to 100 degs. Fahr. Dynamite freezes at about 40 degs. Fahr.

The latest invention in nitro-glycerine preparations is BLASTING GELATINE. Its manufacture is difficult and dangerous, but once made, it is the safest of explosives. Unlike dynamite, frozen gelatine is more dangerous than unfrozen, as a rifle bullet fired in a frozen mass of it causes an explosion, while no effect is produced by the same treatment when in an unfrozen condition. It is less rapid in detonation than dynamite, and is consequently useful for blasting soft rocks into large blocks. It is quite insoluble in water, and may be kept in it without deterioration. Compared with dynamite, its relative sensibility to detonation has been accurately ascertained with the result that while 0·8 grains of cap mixture are required to explode No. 1 dynamite, the best blasting gelatine requires 8

grains. A table is given showing the effective power of different explosives using a 10 gramme charge with a testing apparatus described. The following are a few of the results.—

	Foot Pounds.
Blasting gelatine, consisting of 93 per cent. of nitro-glycerine and 7 per cent. of nitro-cotton, ...	1·400
Nitro-glycerine, ...	1·270
No. 1 Dynamite, ...	900
No. 2 Dynamite, ...	530
Curtis & Harvey's Extra-Strong Gunpowder, ...	272

The increasing demand for strong explosives is clearly shewn by the rapid rise in the annual sales of dynamite, rising from 11 tons in 1867 to 5,500 tons in 1877 and 9,500 tons in 1882. Closing his paper, the author says—"From the foregoing it will be seen that of the three explosives—nitro-glycerine, dynamite, and blasting gelantine—the latter is the safest in every respect as regards handling, transport, and storing. J. H.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 20th DECEMBER, 1883,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

JAMES M'CREATH, Esq., President in the Chair.

About thirty members were present.

The Minutes of the last General Meeting were read by the Secretary and confirmed.

The following Gentlemen, who had been duly nominated at a meeting of Council, were elected by ballot, and admitted as Ordinary Members:—

WILLIAM COOK, Germiston Street, Glasgow.
THOMAS. P. STEWART, 8 Fitzroy Street, Glasgow.
JAMES HAMILTON, Burnbank Crescent, Hamilton.
ROBERT TERVET, Clippens Oil Works, Johnstone.

DISCUSSION OF MR BEILBY'S PAPER ON YOUNG & BEILBY'S PROCESS FOR THE TREATMENT OF COAL.

The PRESIDENT, while remarking that Mr Beilby was not present, invited discussion on his paper.

Mr PRENTICE said as he occupied a considerable portion of time in the discussion of this question at last meeting, he had no desire to say much more on the subject; but perhaps he would be permitted to say a word about the costs before the close of the discussion. He was exceedingly glad that Mr Beilby had now given an estimate of the cost and profits of this process, and for which he thought they were all indebted to him. There was a great

difference between Mr Beilby's estimate and his (Mr Prentice's) as to costs; but he was glad to see that Mr Beilby had accepted the estimate which he had made of the value of the tar and ammonia obtained from a ton of dross. In regard to the costs, his estimate was based on the working of 20 tons per day by a coalmaster at his pithead, which, as he mentioned before, would produce as large a quantity of gas as could be utilised about an ordinary colliery; whereas Mr Beilby's estimate of costs was based on the working at a large work where he supposed 500 tons per day would be put through. It was easy to understand that the costs of working 500 tons per day and the costs for working 20 tons per day were very different. In regard to the expenditure for plant and depreciation, there was also a considerable discrepancy between Mr Beilby's estimate and his, partly arising from the fact that Mr Beilby put nothing in for the cost of raising steam, and very little for depreciation of plant; but he was quite content to leave this to those who might try the experiment for themselves, and he still thought it would be found that the cost of the plant and the expense of maintaining it would not be less than he had stated. At all events he thought it was clear from the whole of this discussion that there was no inducement for any one to adopt this process where it could only be carried out in a small way; nor at any work where the whole of the gas could not be utilised.

Mr ROWAN said there was one point upon which he should like to make an observation. He noticed that Mr Beilby quoted in his paper (on page 169), and also repeated (on page 217) in the communication which he made in replying to the last discussion, an estimate of 45 lbs. of sulphate of ammonia recovered per ton of coal; but it appeared from the paper which he read that that was the quantity of ammonia recovered by Mr Young at the Pentland works, working with the coal producer which was illustrated in fig. 1, page 168, and which worked in a very different way from the coal producer or retort Mr Beilby specially described, in figs. 2 and 3, as the one being erected at the Oakbank works. In the former the coke was wholly consumed by means of air passing through grate bars and with steam, and in that way the nitrogen in it was freed

and recovered as ammonia; whereas in Mr Beilby's plant as erected at Oakbank, the coke was withdrawn and put into separate producers placed alongside the bench of retorts, the gas from these not being treated for ammonia. Now, Mr Beilby had shown in his tables—and it had been proved by analysis by Scheurer-Kestner and others—that more than half of the nitrogen existing originally in the coal is found in the coke; so that if he withdrew the coke in this process at Oakbank, the speaker could not see that he could expect to get the same yield of ammonia as Mr Young, who burned the whole of the coke in his retorts. Therefore, he submitted that the estimate of 45 lbs. of sulphate of ammonia per ton of coal, although it had been realised by Mr Young, very likely might not be realised by the apparatus which Mr Beilby specially described; and at anyrate he should like to ask, under these circumstances, what ground Mr Beilby had for estimating a yield of 45 lbs. per ton in his coal retorts.

Mr HENRY AITKEN said his object in speaking was more directly to correct what he conceived to be errors in the preface to Mr Beilby's paper than to criticise the paper, for reasons which he should afterwards give. As to the difference in the products to be got from coal in treating it at different temperatures, as contained in page 158, it was a well-known fact that they might treat coal and make all into permanent gas and coke, and make almost no liquid; or they might make it almost all liquid and coke. One point he would take exception to was at the bottom of page 159:

"In both cases a yield of ammonia corresponding to from $\frac{1}{8}$ to $\frac{1}{10}$ of the total nitrogen of the material is obtained."

Now, that estimate of the quantity of ammonia to be got was, in his opinion, very much under what was got by other systems. It was a well-known fact that in distilling in the manner mentioned by Mr Beilby at the top of page 159, in the close furnace the amount of ammonia got was about a fourth of the gross amount of nitrogen contained in the coal. Mr Beilby went on to say at the bottom of page 159:

"The volatile products from beehive and other ordinary coke ovens have a general character which classes them between paraffin oil on the one hand and gas tar on the other."

So far as investigation had gone in those oils, that remark was true; but the investigation into them was yet only of a very limited character; and it could not yet be said what the nature of these oils was. That they were oils was certain. The next point was:

"The yield of coke is increased, and its quality is improved by allowing the oil or tar vapours to pass through the red-hot coke."

That was quite true in the ordinary process of making coke in a bee-hive oven. The gases ascended, and parted with so much carbon and made the coke better; but it was equally true that where the gases were drawn down through the coal in place of allowing them to ascend through the heated coke, the coke was likewise improved. Indeed, he might say it was more improved than when the gases were allowed to ascend in the usual manner; for this reason, that the gas was better filtered through the small coal than by passing up the cracks in the coke. The next point he called in question was a little further down the page:

"The impoverished gases will thereafter yield a much smaller return of condensable hydro-carbons and the uncondensable gas has a very low illuminating value."

He did not quite understand this sentence, reading it with what went before; because Mr Beilby was there talking about coke ovens. Now, the gases, as they ascended in the usual way of making coke in the oven, were burned, so that there were no liquid products got from them. On the other hand, when the gases, as they were distilled from the coal, were taken down, and the ammoniacal and oil products taken out, the gas had an illuminating power of 8 to 14 candles, the coal used being common coal. The next sentence he had not been able to understand. It was:

"Apart from such a system as is here indicated, the yield of coke would be from 10 to 15 per cent. lower."

Whether that applied to the ordinary system of making coke where admittedly there was a loss of 10 to 20 per cent., he did not know; but in carrying out the system in bee-hive ovens,

where properly conducted, the loss would not be 10 or 15 per cent.; it would only be 2 or 3 per cent. The next point was:

"The coke-maker . . . . . was fully aware that if he attempted to take away volatile products the coke at once failed to satisfy his customers."

Now, that was directly opposed to the fact. The real fact was, when the volatile matters were taken off properly and the coal coked at a proper temperature, the coke was very much improved in quality. So much was that the case that coke made in this way from ordinary Slamannan Lady-grange coal had been pronounced by three of the best founders in Falkirk as equal to any Durham coke they had ever used. Then he went on to say:

"There has been a further obstacle; he has always been met by the necessities for an increased expenditure on plant and a heavier cost in handling the material."

This might be so as regards other systems; but by the system he referred to there was no increased cost when they took into consideration that by it they could make one oven do practically the work of two; and as it only took £20 to £25 per oven to take out the volatile products and get the ammonia and oil, and as the cost of an oven was about £40, it was quite clear there was no extra expenditure in getting these products, so far as the plant was concerned. As to heavier cost of handling the material, there was no difference in this respect, because the ovens were the same, and the manner of filling and drawing was the same whether worked by manual labour or machinery. He would next call attention to p. 161 where Mr Beilby narrated what had been done in the Scotch pig-iron trade in the recovery of tar and ammonia from the gases of blast furnaces. He said:

"Published reports indicate that the Messrs Baird and others have met with considerable success in this application."

"Considerable" was not the word to apply in the circumstances; because it had been a very great success, and would still be a greater. The word "considerable" could not be applied to a system where they reduced the cost of an article 15 per cent., which was about what the saving amounted to. He was not in the Messrs Baird's secrets, but he had heard from a fair authority that about

32 lbs. of sulphate of ammonia and 12 gallons of tar or oil were got per ton of coal charged into the furnace. Mr Beilby went on to say:

"The enormous cubic content of the blast furnace, &c. . . . . are hardly compatible with the set of conditions most favourable to carrying out the distillation of coal for making and recovering products."

He took exception altogether to that statement. The blast furnace was eminently the place where they could do this work; for the simple reason that the products could be got with comparatively little trouble. He thought they were only at the beginning of this matter in blast furnace practice. About seven or eight years ago he advocated this plan, but could get no one to adopt it. He was then told by practical men that it was a visionary idea,—that there was neither ammonia nor tar in these gases to be got. Scientific men backed them up, and he could get no one to listen to him nor allow him to adopt the process. They were on the verge of still greater improvements, because, as some of them knew, in the iron ores used in Scotland (principally carbonates of iron) which they took much trouble to calcine, all the carbonaceous matter and ammonia were in that process put into the air. In fact, in the process of calcination the whole iron in the ore was converted to metallic iron and then into a peroxide, in which state it was put into the blast furnace: which simply meant the use of more carbonaceous matter and undoing what they had done before. No more ridiculous thing than that could be conceived; whereas, if the carbonates of iron were put into the blast furnace, the ammonia and oil in the iron ores would be secured, and, by adding steam, the carbonic acid in the iron ores would be expelled. The presence of carbonic acid in the raw iron ores was the main cause why such ores had not not been used in a raw state in the blast furnace heretofore. Many had tried to smelt carbonates of iron in the raw state, and had found it impossible to do so almost to any extent, because the carbonic acid would not leave the ores owing to the absence of steam, and when it arrived at the hearth of the blast furnace it would not part from the ore; and hence the ore was simply melted and not reduced, and the iron and cinder came away together as earthy matter and prot-

oxide of iron; or if there was an excess of coaly matter in the ore it was reduced to malleable iron in the blast furnace, and in that state had to be cut out. He therefore said this process of extracting the ammonia and tars in the blast furnace was but yet beginning, and, in his opinion, it had a bright future.

The PRESIDENT said perhaps Mr Aitken would indicate what he meant by 15 per cent. of the cost of making iron.

Mr AITKEN said, taking the cost of iron at, say 40s; 15 per cent. on that would be 6s. He believed that was something like what was being got. Referring next to Mr Beilby's remarks on the Fuel-Gas Industry on page 161, Mr Aitken said he must say he was at one with Mr Beilby and others with respect to the subject of the work they attempted to get out of coal. He came now to page 162, and more particularly to the analysis of gas made in the usual type of producers where air was used to consume the coal. The amount of nitrogen they would see given was 60 per cent., and he thought that in this paper,—and he had read it in many others,—this 60 per cent. of nitrogen was considered to be an unmixed evil. Now, he might be considered most unorthodox,—if he could use such an expression,—when he said this was not by any means an unmixed evil. It was like many things, so at first glance; because when they considered the way in which they attempted to burn gas, more particularly below boilers, if the 60 per cent. nitrogen were not there they simply would make almost entirely smoke. It was the presence of this nitrogen that enabled them to carry on their processes even in the present very imperfect manner. Talking generally of water gas, there was no subject that had employed the inventive genius of this country to such an extent as water gas. This power of getting heat out of water had had a perfect fascination for experimenters. He would not plead that he was himself quite clear of it, because, some years ago, he had taken out a patent jointly with Mr Young for making water gas. In this country water gas had not taken root, but in America a great many gas works make water gas, and a journal called the *Water Gas Journal* had been started in order to advocate the process. Referring next to the statement at the bottom of page 163, as to

the value of the resulting gas, Mr Aitken said no doubt this was true; but at the first glance one would naturally suppose this enormous amount of hydrogen performed a greater amount of work than it did. The work performed was according to the weights of the respective gases. Here the weight of hydrogen and the weight of carbonic oxide were pretty nearly the same. This brought him as far as he had any intention of going, except to wonder why the word "incineration" was used. The whole process was simply burning coal in an atmosphere of oxygen and hydrogen; whereas, in the ordinary fire, the atmosphere was oxygen and nitrogen. That brought him to Mr Beilby's paper proper, and he did not wish to enter into, or to say anything about that paper, or the results given in it, beyond that it was a very excellent paper. His reason for not saying anything was that he was the author of a system of making gas to be used in boilers and furnaces which he believed was infinitely superior to the process here described, in respect both of the capital and the labour required; and anything he would say would be to find fault with this process, and perhaps praise his own; and as it was Mr Beilby's paper, and not his, that was under discussion, he thought it only courteous to him that he should say nothing more.

Mr DIXON said, in recovering the ammonia the saving might be 6s a ton of iron, but how much did it take to recover that 6s?

The PRESIDENT said the estimate of Mr Aitken included the cost of the acid and of the work, but allowed nothing for plant.

Mr DRINNAN would like to have some idea of the cost of the plant necessary to recover the ammonia.

Mr ROWAN said he might give one little bit of information to Mr Drinnan in reply to his question. The cost of plant necessary for treating about 12 tons of coal per 24 hours and recovering the ammonia and tar and, of course, making combustible gas (he alluded to the Wilson producer with the Addie recovery plant combined) was about £40 per ton of coal per day treated. That was to say the plant would cost about £500, and that proportion would hold good for larger quantities. This was about half the cost Mr Beilby estimated for the plant he described. He should

like to know the reason why Mr Aitken thought it would be impossible to burn gas without the presence of nitrogen in it. For his part he should be very glad if he knew how to make such gas cheaply.

Mr AITKEN said if they took a block a foot square, which was no uncommon block of gas to force into a combustion chamber, they would simply make the flame round the outside. It was so rich behind the air, they could not get into the body at all. Although the tars might presently be considered to be worth very little, he should like to ask what were the first tars made in gas works thought worth? They were worth nothing; but after some thirty or forty years of careful working on the part of chemists, they now knew what could be made of them. The utilisation of blast furnace tars was only a question of a few years, and no one could tell what might be got out of them. Some five or six years ago, he took some of the oils he had made in coking coal, and passed them through layers of broken bricks heated up, and he converted the oils of the paraffin series into those of the tar series. So soon as they had the nature of these oils thoroughly known, he expected their value to be something more than 1d a gallon as at present.

The PRESIDENT then announced that the discussion would be adjourned to enable Mr Beilby to reply.

DISCUSSION OF MR ROWAN'S PAPER ON GAS FIRING FOR STEAM BOILERS.

The PRESIDENT asked Mr Rowan how it was that in gas firing they could obtain a higher calorific intensity with the gas from a gas producer than from burning solid fuel.

Mr ROWAN replied that on page 221 they had a comparison between pure carbon and carbonic oxide, so that if they substituted coal as burned in an ordinary furnace for the carbon, and producer gas for the carbonic oxide, they would not be far out if they still applied this comparison. In addition to this, in firing boilers with

gas they never required to cool them after they once began to fire, as they did frequently in charging and cleaning fires worked in the ordinary way. So that for that reason, and also from the fact that they had cleaner surfaces, a higher efficiency was realised from boiler surfaces, although this comparison might not be carried out to the full.

The PRESIDENT said on page 229, the author said :

"The result [of Mr Darby's trials] he has stated to be an average economy of 27 per cent. in favour of the gas-fired boiler."

whereas, as he read Mr Darby's report, it only gave this percentage of additional steam produced in the same time. Looking at the tables, the quantity of water evaporated by gas firing was larger than that evaporated by hand firing, but by a much less percentage than 27 per cent., and, if they made allowance for the steam used in the gas producer, the two systems were nearly on an equality.

Mr ROWAN said they would find in the last paragraph of his report, page 224, that Mr Darby said :

"The gas-fired boiler . . . . gives 26·9 more duty."

He (the speaker) took it roughly at 27. Of course, the extra evaporative efficiency of the boiler was part of the economy besides the actual saving of fuel. If they could get 26·9 per cent. more power out of a boiler for the same time, they were certainly saving fuel.

Mr AITKEN said their Scotch coals contained from 5 up to 20 per cent., of water, and in this locality the Ell Coal had generally as much as 15 per cent. of water when taken from the "close places." If that was used in a boiler fire, or made into gas by any of the arrangements proposed, the whole of the water was converted into steam, so that they had 3 or 4 cwt. of water per ton of coal going in along with the gas and preventing it from burning. This was not decomposed into hydrogen and carbonic oxide as the steam was in the water gas making process. It was passed in as water into the combustion chamber, and of course prevented the gas from burning there with the rapidity or at the temperature which was wanted. So much was this the case, that he had been able to take ordinary

hydro-carbon gases, and rob them of this water and also their oils, and thereafter use this dry gas. He had taken out up to 35 gallons of water from a ton of coal. This was something like 3½ cwt. of water, which practically made it into a mixture of steam and gas, preventing it from burning or giving the results desired. By using that dry gas, he was able to do work in one-half the time compared with the water-saturated gas, showing the bad effect of these aqueous vapours in the combustion of the gas. Until the gases were freed of their water, they could not be used with economy.

The PRESIDENT said, comparing the French experiments with Mr Darby's, he was very much struck by the greater success in forming carbonic oxide in the French experiments than in the English ones; but while in the French experiments there was only one per cent. of carbonic acid produced, there was 5 to 6 per cent. in the English experiments. Perhaps Mr Rowan might be able to tell them whether any improvement in that respect had been made now or whether this might be owing to not taking such good care to prevent air getting into the gas producer in the English as in the French experiments.

Mr ROWAN thought that was the only case in which it was high; and in the earlier tables they seemed to have been making very bad gas indeed, because there was nothing except carbonic acid and nitrogen, but he might say that the precautions taken in the gasogene were most elaborate to prevent any excess of air over and above what was required in burning the coal to carbonic oxide, from entering. Mr Rowan said M. Fichet had regulators and various appliances for preventing air entering when the coal was being charged; and the supply to the various parts of the fire in the gasogene was carefully regulated. M. Fichet also regulated very carefully the amount of air conducted to the furnace under the boiler, so that there should be no cooling in the gas when being burned. These precautions and elaborate appliances rendered this system rather expensive to carry out, so that it had not been adopted largely in France and little, if at all, in England.

Mr DIXON said the most material point of any was whether they could adopt such a process with a moderate amount of outlay. It was a very desirable thing to burn coal without producing smoke

and annoying their neighbours, and if it could be done with a reasonable outlay at first and in upkeep it might be tried at collieries. At page 234, Mr Darby said it took six men to fire seven boilers. That was not the experience of this district. With that they should have had very perfect firing. Therefore, he thought if Mr Darby employed six men to fire seven boilers, the saving from this process with as many boilers being fired by one man was not so apparent.

The PRESIDENT said Mr Rowan's information as to this process of Messrs Addie & Sons for the recovery of ammonia in this producer was not so full as many of them would wish. He asked if there was any place in the neighbourhood where they might see it, and also the automatic producer in operation.

Mr ROWAN—Not in Scotland. Addie's process as applied to gas producers, was being carried out at several works, but this application was not at work yet at any place in Scotland. Neither was the automatic producer as yet in operation here, although there were several in England. The experiments were worked out in the south, by which they hoped to profit in the north. The cost, speaking roughly, of applying gas to boilers where there were several in the range, was about £100 a boiler, and where the ammonia recovery plant was added, it was, again speaking roughly, double, or £200 per boiler.

The PRESIDENT—Do we take it, each boiler so fired gives 27 per cent. more steam?

Mr ROWAN—Yes, and the by-products from the dross used are so much to the good in addition to its extra duty.

The PRESIDENT, in proposing a vote of thanks to Mr Rowan, said it was quite evident they had a great number of workers in this field, and he hoped they might have more papers on the subject. (Applause.)

DISCUSSION OF MR COWAN'S PAPER ON THE VALUATION OF IRON WORKS.

The PRESIDENT introduced the discussion on this paper, and announced that Mr Cowan was not able to be present.

Mr DIXON thought Mr Cowan had very clearly stated what

was the usual practice among mining engineers. Of course, the whole matter was to get a man of skill to draw the proper conclusions. The greatest difficulty he had was to value places where there were no profits being made, or ever had been made. If they got profits from books, verifying statements for themselves, they could draw a pretty shrewd conclusion; but where the whole thing was problematical, and they had to imagine a good deal to see a profit at all, that was where the difficulty of bringing those rules to bear on the subject lay. In that case they had to take a sort of common sense view of the matter, and, as a rule, value it on the auction value of the plant, and how much it would take to clear the ground.

The SECRETARY drew attention to an error in figures near the bottom of p. 239, which should read ·0357 instead of 0·357. He said that, with valuations extending over such a long space of time, it was apparent the percentage must be so high as to bring it practically to a speculative value.

Mr AITKEN said perhaps he might state that over the last 25 years he had had to fight the tax people in this matter, and the invariable position he took up was this: what was the work worth per annum? what would they get for it? That was all they were entitled to, and he never entered into figures with them. He thought that was the proper way to look at it. What was the rental of such a subject? what would it bring?

Mr DRINNAN said he had imagined the valuation was to be for rating purposes; and, while reading the paper, he wondered what profit had to do with such a valuation; because, as Mr Dixon had said, there was very often no profit at all in those times; and, supposing there was, he thought that would be a too curious inquiry into the business of employers. He thought the plan in England in regard to the valuation of going properties—for rating purposes at all events—was to allow a certain rate per cent. on the capital laid out, irrespective of the profit that could be obtained on it. He thought it was about 5 per cent., making slight deductions for depreciation, &c.

The PRESIDENT thought in these times they were very fortunate if they could get all the information that would enable them to make a valuation on the principles shown by Mr Cowan. When

that was got, it was a very easy way of valuing. It occurred to him that the author allowed a very small sum for the value of stocks and stores for such a large work,—only £30,895,—and he allowed the purchaser nothing at all for interest or profit on this sum. In a large concern, the purchaser would require interest for his money, and something more as profit on what was invested in stocks and stores and book debts.

After a vote of thanks to Mr Cowan for his paper, the discussion was closed, on the understanding that Mr Cowan would have an opportunity of replying in writing.

Mr COWAN afterwards communicated the following:—

I much regret that there should have been so little discussion on this important subject; especially as the paper only gave an outline of general principles, and left untouched such a wide field as the processes of examination of the several subjects, which, when combined, form a vast mining undertaking such as I have sketched.

True, the subject is one which only men of matured experience can deal with; and as the problems involved not only require a technical but a financial training, the most important point for parties most interested is, as Mr Dixon states, to get a man of skill to draw the proper conclusions. This should not be such a difficult matter, there being a fair sprinkling of members of this Institute who should be able to do so.

It is gratifying to find that the mode of valuing advocated by me is now the usual practice amongst mining engineers. Some twenty years ago this was not so, at least in Scotland; my late partner, Mr John Mackenzie of Dundyvan Iron Works, being at that time the chief representative of this school of valuing.

Both the President and Mr Dixon hint that there are difficulties in getting at the data necessary for such a valuation. In my own practice I have not found this to be so. In a list of upwards of a score of iron works now before me; besides a larger number of collieries, in the valuation of which I have been engaged, I have never had any great difficulty in getting the information; my greatest difficulty always being in knowing exactly what to ask for, and in estimating future out-

lays and outputs, and the periods over which these outlays and outputs should extend, as this is most essential in determining the annuities on which the valuation is based.

In cases where no profits are being made, nor have been made, nor are likely to be made, there should be no difficulty. It is certainly a most unpleasant duty to inform the partners of such a concern that it is only worth breaking up value; but, as Mr Dixon puts it, the common sense view is the auction value, less the expense of clearing the ground; and this is the only value such a subject can have.

Mr Aitken's remarks I take to agree entirely with the views advocated in the paper.

Mr Drinnan, I fear, has in reading the paper found it a little tedious and dry. Had he been able to follow it, he should have seen it had nothing to do with rating values, but with a much more important value, viz., the return an investor is likely to get for his money when invested in a manufacturing iron and mining concern.

Respecting the president's remark that the author had allowed a very small sum for the value of stocks and stores for such a large work (only £30,895), I have to say that the figures are only intended to illustrate a principle, and not in any way to illustrate the practical financial working of such a concern. As the examples of valuing are all taken from practice, the figures are purposely distorted in order that, although the examples may be recognised, the figures will in no way expose the position of the concern to which they apply.

The President further remarks that the author

"Allowed nothing at all to the purchaser for interest or profit on the sum invested in stocks and stores. In such a concern the purchaser would require interest for his money, and something more as profit on what was invested in stocks and stores and book debts."

I beg most respectfully to differ from the president's view that I have not allowed for a return on the floating capital. The rates at which the respective annuities have been discounted are supposed to be sufficient to cover the interest on the floating capital necessary to work the concern. The floating capital varies

2. Behaviour in Currents of Air.

The following experiments show that the lamp, as presently constructed, is too sensitive to currents of air to permit of its being used for ordinary purposes in the mine.

On being carried from the lamp room to the pit in a breeze, two of the Ballardie lamps were extinguished: while one Ballardie lamp, a Williamson, and a Protector continued to burn.

Carried backwards and forwards in an intake current, with a velocity of 785 feet per minute, in two out of four trials the Ballardie lamps were extinguished, and the other lamps remained burning.

Going in an intake with a moderate velocity of air, all kept burning; coming out against the current one of the Ballardie lamps went out at a point where the velocity was increased owing to a contraction of the mine. Coming up the shaft against the current the second Ballardie lamp went out. At the pithead the third Ballardie lamp was extinguished in a gust of wind. In these several instances the Williamson and the Protector lamps continued to burn.

3. Behaviour in Gas.

The Committee had no means of ascertaining the relative proportions of air and carburetted hydrogen in the gas experimented with. The experiments made are stated in detail, and fairly indicate the usual conditions in which fire-damp is found in practice.

1. *At the top of a fall in a stoop-and-room working.*—The Davy lamp shewed a blue cap: Protector went out: Williamson, flame enlarged: Ballardie, flame enlarged till it filled the lamp, which was then withdrawn and continued to burn.

2. *In a hole in the roof of main intake.*—Davy lamp shewed blue cap: Mueseler went out: Ballardie went out.

3. *In a hole in the roof at the face of a working-room next a slip.*—Tried with Davy, Mueseler Protector, and Ballardie. The Ballardie had to be raised twelve inches higher than the Davy and six inches higher than the Protector before signs of gas were

seen on the flame; raised a little higher the gas exploded and put out the light in the centre chamber, but it continued to burn in the lower chamber until the lamp was withdrawn.

With another Ballardie lamp the gas exploded in the lamp and extinguished the light.

The same two lamps were tried again. No. 1 put up somewhat quicker with same result as in former trial. No. 2 was put up cautiously: flame elongated till it could be seen in the top chamber: lamp withdrawn: put up again with same result: put up a third time till the gas exploded in the lamp, when the flame was extinguished.

4. *Over an ordinary gas burner.*—In several experiments with the Ballardie lamp the light was extinguished in the centre chamber; and the gas continued to burn in the lower chamber until the lamp was withdrawn.

In several other experiments the flame enlarged considerably, and elongated into the upper chamber.

In one experiment it was seen that oil with which the gauze dividing the lower from the middle chamber had been saturated was burning. The oil escapes too readily from the oil vessel, and is apt to prolong combustion inside the lower chamber; it also makes the lamp disagreeable to handle.

The greater number of the Committee's experiments were made with the air inlets full open.

4. Conclusions.

In the opinion of the Committee, this lamp is unsatisfactory as a carrying lamp, being too easily affected by air currents. Its weight is also an objection, but not a serious one.

As a safety lamp, its behaviour during the experiments in gas was disappointing; and the members of Committee feel that they would not be justified in putting it into the hands of a workman where the presence of fire-damp is to be apprehended.

The inventor claims that its chief merit lies in its being a working lamp. Its failing to satisfy the other requirements limits very much the conditions in which it could be used as a working lamp; and this is the more to be regretted, that the light given is so much superior to that of other safety lamps.

Although the area of glass exposed is large, the Committee do not consider the lamp more liable to be broken than other glass safety lamps in use.

Reported by JAMES GILCHRIST.
JAMES HASTIE.
ROBERT BEITH.
ARCH. BLYTH.
JAMES BARROWMAN.

DISCUSSION.

On the invitation of the President,

Mr BALLARDIE, in reference to the behaviour of the lamp in currents of air, said he was scarcely prepared to hear that it was so very delicate. He considered it a mere mechanical difficulty, which could be got over by introducing a gauze wind buffer in the air chamber. As to its behaviour in gas, he thought the flame showed very perfectly the nature of the mixture into which it had been placed when it elongated. Certainly there was nothing unpleasant. Had the gas been in a greater volume it would have put out the light. He thought the lamp itself showed pretty much the nature of the atmosphere it had burned in.

The discussion was adjourned.

NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES.

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AMERICAN INSTITUTE of MINING ENGINEERS.

Papers read at the Boston meeting, February, 1883; and at the Troy meeting, October, 1883.

A SUGGESTED CURE for BLAST FURNACE CHILLS, by Mr Henry M. Howe. This is a suggestion for the cure of those chills in the hearths of furnaces which are due to scaffolding, by the introduction of vapourized petroleum or finely divided anthracite with the blast, so as to raise the temperature of the hearth above the melting point of slag. Mr Howe enters into the rationale of his proposed process in considerable detail, and gives in appendices full notes of his assumptions, and calculations of the temperatures reached by the products of combustion of the different substances. From the discussion it appears that frequent success has attended the introduction of steam to the hearth, and the lowering of the amount while increasing the temperature of the blast, in the earlier stages of chill; and it is doubted whether this proposed method would be of advantage except in more confirmed cases.

THE LINKENBACH BUDDLE, by Mr R. Rothwell, is a description, illustrated by a sketch, of a buddle devised by Herr Linkenbach of the Ems Lead and Silver Works. Unlike the German and other buddles, the table in this one is stationary, while the washing apparatus revolves. In order to economise cost and space, three tables are usually superimposed on the same foundation. The advantages claimed for it are, simplicity of construction, durability, perfect control of water, of degree of concentration, and of the number of classes into which the ore may be divided.

A WATER GAS FURNACE at ELGIN, ILL., by Mr P. Barnes. This paper is a statement of the details of an unsuccessful attempt to take water gas from a cupola furnace. Pre-heating of the blast and of the steam was fully accomplished, but the heat was not intense enough to secure the complete fluxing of the furnace; and the slag was chilled by the steam blown in during the gas making, and left with so little fuel in or near it that it could not be re-melted when the blast was turned on again. It was found that in order to compete with direct coal firing, when the price of coal was 20s per ton, the gas had to be furnished at less than 2½d per 1000 cubic feet.

SMELTING NOTES from CHIHUAHUA, MEXICO, by W. Lawrence Austin, Ph. D. This paper consists of a notice of the very primitive operations employed at Santa Barbara for the reduction of Silver from low grades ores mixed with zinc-blende and antimonial and arsenical compounds. The furnaces there are each of one ton capacity, built of adobes (sun dried bricks), some five feet in height and twelve inches square at the tuyeres, and cost about 28s each. The ore is fluxed with litharge and slag, and charcoal is used for fuel. The cupellation hearths are also built of adobes, and the silver is melted down in old mercury flasks. The whole cost of roasting, smelting, and refining these refractory ores amounts to about £4 per ton. At one works the blast was driven by man power, the whole concern being of home manufacture, bellows, furnace, and all.

RŒSSLER'S METHOD of MANUFACTURING SULPHURIC ACID and SULPHATE of COPPER, by Arthur F. Wendt. This method, which is patented in all commercial countries, originated accidentally during experiments made by Dr. Rœssler for the purpose of abating the nuisance created by the discharge in the air of sulphurous and sulphuric acid fumes generated in the process of parting bullion at minting establishments, &c. It consists of forcing the sulphurous gases, mixed with air and steam, through a solution of blue vitriol, contained in a leaden converter, by means of a Korting blower. The sulphurous gases are oxidized to sulphuric acid with the formation of a sulphate of the sub-oxide of copper, which is re-oxidized by the oxygen of the air to blue vitriol again. The reactions of reduction and oxidation go on simultaneously in the converter; the blue vitriol merely acting as a carrier of oxygen exactly as nitric oxide does in the ordinary lead chambers. The converter is also employed to manufacture blue vitriol (sulphate of copper). For this purpose it is filled with water, into which copper is introduced in some form. As the sulphurous fumes generated in all metallurgical operations contain a small percentage of suphuric acid, this only is at first absorbed; dilute acid results, which immediately attacks the copper, blue vitriol is formed, and acts on the sulphurous gases as already described. The blue vitriol is then either crystallized or its copper precipitated. It is stated that for the manufacture of sulphuric acid in lead chambers, at least 8 per cent. of sulphurous acid should be present in the gases; and it is claimed for this system that it can profitably utilize gases with less than 1 per cent of sulphurous acid. The paper finishes with an account of the many unsuccessful attempts previously made to abate the evil of escaping fumes.

The COLORIMETRIC DETERMINATION of COMBINED CARBON in STEEL, by Mr Alfred E. Hunt. This method, known in this country as Eggertz's Process, is based on the colour given by carbon to a nitric acid solution. It is very rapid and therefore much used in steel works. The accuracy of the process depends on the selection of colour standards of as nearly as possible the same chemical composition, and which have been subjected to similar mechanical treatment as the samples to be tested. The difficulty of determining the exact condition in which the carbon is associated with the iron, and, therefore, of selecting a standard in which the carbon is united in the same way, the writer finds to be the only uncontrollable error of the method. He discusses every detail in the process down to the different methods of holding the tubes when matching the colours. He does not approve of permanent standards of organic substances, but finds those made by Eggertz and Stead's methods reliable. In open-hearth steel works only a few minutes can be allowed for a determination of carbon in the tests taken from the furnace, and Mr Hunt gives the methods practised by him, by which he is able to get results from three to ten minutes after the drillings have been obtained.

J. G.

CLEVELAND INSTITUTION OF ENGINEERS.

Session 1882-83 (No. 5, April 1883). The SALT DEPOSITS of MIDDLESBROUGH, and the MODE of WINNING THEM. An Address by Mr T. Hugh Bell. The conditions under which rock salt is supposed to have been deposited; the geological formations in which it is chiefly found; its physical properties and chemical composition, are all gone into by way of introduction. The method of boring to the salt deposits, and the system of tubing the bore hole and pumping the brine are then fully described. The treatment of the brine in the salt pans to form the salt of commerce is next gone into, and the address is concluded by an account of some of the many uses to which it is put.

An account is also given of a subsequent visit of the Members of the Institution to

Messrs Bell Brothers' Salt Works at Port Clarence, when Mr Bell supplemented his address by shewing and describing many details connected with the system of boring for the salt, and pumping and evaporating the brine.

It may be added that any one interested in this subject will find a most exhaustive history and description of salt mining in Cheshire by Mr Dickinson, Inspector of Mines, in his annual report for the year 1881.

Session 1882-83 (No. 6, May 1883). A Paper on the EXHAUST INJECTOR, by Mr A. Slater Savill is given in this number, with the discussion thereon. This apparatus is designed to utilize the exhaust steam of engines, which it returns to the boiler along with the feed water. It acts like a Giffard's Injector, but with this important difference, that, paradoxical as at first sight it appears, exhaust or waste steam forces the feed water into the boilers, instead of high pressure steam taken directly from the boilers. It appears that this is accomplished without causing back pressure; it rather, as is shewn by two indicator diagrams, takes away back pressure which previously existed. Steam at atmospheric pressure will rush into a vacuum at a velocity of 1888 feet per second; and taking advantage of this fact, the water flowing into the injector causes the necessary vacuum, and the inrushing steam imparts to it sufficient momentum to force it into the boilers. The construction and action of this ingenious contrivance are explained by means of drawings.

Session 1883-84 (No. 1, November 1883). "On the EDUCATION of MECHANICAL ENGINEERS" is the title of a Paper by Mr Wm. Ripper. Under the following heads he discusses this important subject:—

(1).—Mechanical Engineers and their work.

(2).—The training required to render them efficient, including some account of Continental methods of training.

(3).—The means already at their disposal in this country for obtaining an efficient training, including a consideration of the subject of School Workshops.

(4).—Suggestions for the direction of future efforts to promote the welfare of Engineers and Engineering in this country.

A mass of information is supplied by the author regarding the methods adopted on the Continent to train young engineers: and the training provided at the various Colleges and Institutions in this country also is fully entered into.

J. M. R.

The TRANSACTIONS of the AMERICAN SOCIETY of CIVIL ENGINEERS for September, 1883, contain a very full account of the REBUILDING of the MONONGAHELA BRIDGE at PITTSBURGH, PA., to a new design by G. Lindenthal, C.E. The two principal spans are 360 feet each, and are of the Pauli truss type, which, especially where there are two or more spans, has a more pleasing appearance than the parallel lattice or truss girder form. An interesting part of the construction was that the traffic was not suspended, but was carried on by means of the old bridge till the new one was sufficiently far advanced to take it. The old and new bridges were nearly on the same line, but the latter is about 20 feet higher than the former. The principal parts of the bridge were constructed of steel, and the following are some of the tests:—

For Compression.
- Elastic limit: 50,000 to 55,000 lbs per sq. inch.
- Ultimate strength: 80,000 to 90,000 lbs. per sq. inch.
- Elongation in 8 inches: minimum 12 per cent.
- Reduction of area at fracture: minimum 20 per cent.
- Cold bending: 180 deg. around its own diameter without crack.

For Tension.
- Elastic limit: 45,000 to 50,000 lbs. per sq. inch.
- Ultimate strength: 70,000 to 80,000 lbs. per sq, inch.
- Elongation in 8 inches: minimum 18 per cent.
- Reduction of area at fracture: minimum 30 per cent.
- Cold bending: to a loop 360 deg. around its own diameter without crack.

R. S.

PIT PONIES, by J. A. Longden, CHESTERFIELD, and DERBYSHIRE INSTITUTE of Mining, Civil, and Mechanical Engineers. Vol. IX. Part IV. In an exhaustive paper Mr Longden deals with this subject under the headings of "THE ANIMAL," including FEEDING, SHOEING, and STABLING; and "WORK," showing, from what has been done by pit horses, what they may be expected to do.

As to FEEDING, he shows how much depends upon the kind and quantity of food, and upon a judicious mixture of various kinds A case is quoted from another paper where, by a change of food, a saving of 9s 5½d per horse per week was obtained, with increased work and improved condition of horses. As the result of careful experiment, oats are shown to have a much larger proportion of husk than other kinds of grain, with about the same percentage of muscle-forming matter as maize. The author therefore concludes that oats should not be used at economically worked collieries; but a mixture of beans, peas, and maize; or, if preferred, the latter alone. Hay should only be given in a sufficient quantity to facilitate digestion. Corn should be bruised and hay chopped, and the two well mixed and damped before being given to the ponies. Tables are given showing for different districts the quantity and kinds of food supplied; the cost per horse per week; the quantity of coal drawn, and the cost per ton.

SHOEING is next considered, and the anatomy of the hoof of the horse explained. The author's opinions as to shoeing appear opposed to the general practice followed by horse shoers, and he quotes Captain Dalton to prove that about three-fourths of all the ailments that horse flesh is heir to may be prevented by good shoeing. The conclusion is—Never pave the soles, frog, or bars, and only cut enough of the horn to bed the shoe properly; while the shoes should be as light as possible, consistent with protection to the horn of the hoof, and without toes or calkins.

Under the head of "STABLING" the position of the stable in the workings; air space for each animal; construction, general arrangement, and cost of building, are discussed and illustrated by diagram.

The WORK of the horse forms the concluding section of the paper, and in it different authorities on the power of the horse are largely quoted, as well as a statement of the writer's own experience. "To obtain the most favourable results horses should not be worked more nor less than eight hours a day." Bianconi, the founder of the Irish car system, found that by working his horses eight hours a day for six days a week, they were in a better condition than when working six hours a day, and seven days a week.

J. H.

The FEEDING and MANAGEMENT of COLLIERY HORSES, by Mr Charles Hunting, NORTH of ENGLAND INSTITUTE of MINING ENGINEERS, Part 4, Vol. xxxii., 1882, pp. 61-116.

The author shews that while oats and hay alone may keep hard-worked horses in con-

dition, it is done at an extravagant cost; but that high feeding can be economically attained, and horses kept in the highest condition, at much less cost, by judicious feeding with crushed mixed food.

But oats and hay alone will not always maintain horses in condition; and the author gives an instance where the horses at a large colliery had got into poor condition, and were unable to do their work, though fed liberally with oats and hay. The food was changed to the following.—

Crushed Peas, 35 lbs., at 34s per qr..	2s 4d.
Crushed Barley, 20 lbs., at 28s per qr.,..	1s 3d.
Crushed Oats, 40 lbs., at 28s per qr., ...	3s 4d.
Bran, 14 lbs., at 7½d per stone, ...	0s 7½d.
Hay, 7 stones, at 9d per stone, ...	5s 3d.
	12s 9½d.

The old food being

Oats, 168 lbs., at 28s per qr., ...	14s 0d.
Hay, 11 stones, at 9d per stone, ...	8s 3d.
	22s 3d.

Showing a difference of 9s 5½d per horse per week. Within three months the horses were in excellent health and condition; and doing more work than with the old plan of feeding.

The value of maize feeding for horses is also shewn. By its use £6000 yearly had been saved in the keep of pit ponies under the author's charge. The following statement shews cost and feeding value of oats and hay, and mixed food and hay.

			Lbs.
Oats, 126 lbs., at 1s 3d per stone,	11s 3d—	Flesh formers, ..	15·1
Hay, 140 lbs., at 10½d per stone,	8s 9d—	Flesh formers, ..	7·0
	20s 0d.		22·1

				Lbs.
Hay, 56 lbs., at 10½d per stone,	3s 6d	..	Flesh formers, ...	2·75
Maize, 56 lbs., at 9½d per stone,	3s 2d	..	Flesh formers, ..	7·25
Barley, 42 lbs., at 9d per stone,	2s 3d	..	Flesh formers, ..	6·75
Peas, 21 lbs, at 1s per stone,	1s 6d	..	Flesh formers, ..	5·75
	10s 5d			22·50

Difference in cost, 9s 7d per week, or £24 18s per head per year in favour of mixed food. Besides, oats has a far higher percentage of husk or woody fibre, which is almost indigestible and therefore almost useless as food.

The following figures shew the saving which has been effected by the author's plan of feeding.

At South Hetton, the system has been in operation for 31 years, the estimated saving during that time being £117,455 and at 17 collieries where the system has been in operation for periods ranging from 4 to 31 years, the total estimated saving is £574,285.

Valuable information in connection with the BUYING OF PIT PONIES AND HORSES; CUTTING AND BRUISING OF HAY AND FOOD, TIMES OF FEEDING, &c., is given; and the paper well repays careful study.

In discussing the paper, Alderman Wilson, Newcastle, said that since Mr Hunting had taken charge of the Newcastle Corporation horses, the saving effected amounted to from £1300 to £1400 a year for the stud of 60 or 70 horses. The horses were in the best possible condition and could compare favourably with any stud in the country. Other gentlemen also spoke highly in favour of the system.

J. HG.

The Minutes of PROCEEDINGS of the INSTITUTE of CIVIL ENGINEERS, Vol. LXXIV., contain Papers on "RESISTANCE of RAILWAY CURVES as an ELEMENT of DANGER" where the tendency of the leading wheels of a locomotive to mount the rails in going round a sharp curve is carefully treated; on "The DIAMOND FIELDS and MINES of KIMBERLEY, South Africa," which gives an interesting description of the geological position, method of working, and machinery of the diamond mines; on "The EDINBURGH WATER WORKS," by A. Leslie, where an interesting historical account is given of the progress made in supplying Edinburgh with water since the year 1621, and describing minutely, with drawings, the various works which now supply Edinburgh; on "The WATER WORKS of PORT ELIZABETH, South Africa;" on "The WATER SUPPLY of PETERBOROUGH," in which the supply is got from a well sunk to the Oolitic Limestone; and on "A DEEP BORING at NORTHAMPTON," by H. J. Eunson. This boring was made with the object of reaching the "Water Stones" at the base of the Keuper Marls in the Trias formation. It was anticipated that they would be found at a distance of 1000 feet from the surface, and that a large quantity of water would be got. A contract was made with Messrs T. Powcra & Sons, who used the diamond boring machine of J. K. Gulland, which was to begin at 24 in. diameter, and be paid for at the rate of £5 per foot for the first 500 feet from the surface, £6 for the next 300 feet, and £6 10s for the rest of the depth over 800 feet from the surface. Operations were commenced in July, 1879, from the foot of a well 10 feet in diameter, which had previously been sunk to a depth of 203 feet; and from this point a shaft 5 feet diameter was begun and carried on till the end of November, when a further depth of 200 feet was reached. This sinking was done through the Lias clay, and was at the rate of eight feet four in. per week. The boring was started from the foot of this shaft. The boring machine is fully described. It consists of an arrangement for turning a circular ring of metal called a crown at the bottom of the hole. The face of this crown is studded with diamonds. These diamonds are the black carbonates found in Brazil, and are about the size of small beans. The largest crown used was twenty-three inches in diameter, and contained fifty stones, having an aggregate weight of 300 carats. This crown cuts its way down, and leaves a solid core, which is drawn up at intervals, giving a section of the strata passed through. The boring rods are steel tubes 3¼ inches in diameter and ⅜ of an inch thick, and are in lengths of five feet. During the drilling, water is forced down these rods to carry away the sediment and keep the crown cool. The crown was revolved at the rate of 140 to 150 revolutions per minute. The core was removed in lengths of 30 feet. The boring extended through 335 feet of Lias clays which were bored through in fifty-nine days, the crown being 23 inches in diameter for 77 feet, 20½ in. for 97 feet, 18 in. for 106 feet, and 15¾ in. for the rest of the hole. It was then bored through 93 feet of sandstones, marls, quartzite, limestone, and shale in thirty days, the core extracted varying from 95 to 100 per cent. of the depth cut. As no water was got at this depth, and as the carboniferous limestone beds had been reached, the boring was stopped. Delays were caused by the breaking of the rods, which generally took place at the collars connecting them, and by pieces of iron getting down to the bottom of the hole. These had to be broken by a pumping chisel before the boring was recommenced. The whole time occupied in putting down the 848 feet, including the time for clearing out the well and sinking the 5 feet shaft, was 590 days.

In the abstracts of papers there is an abstract of one on MINERS' SAFETY LAMPS, by Er. Mallard and Le Chatelier, (ANNALES des MINES. Vol. III., 1883, pp. 35-68), which gives the results of some experiments on the Mueseler lamp.

When this lamp is tilted at an angle of 40 degrees from the vertical, it goes out in ordinary use. When so tilted, however, in an explosive mixture of lighting gas and air with a current of from 14 to 16 feet per second, and the top of the lamp pointing backwards in the contrary direction to the current, it does not go out; but almost invariably fires off the gas. In experiments made by M. Marsaut, it was found that on raising a Mueseler lamp into

a bell containing an explosive mixture of gas and air, the flame will pass through the chimney into the outer gauze.

They recommend that either the distance between the top of the chimney and the gauze be made greater, or an additional gauze be put on; or (as done in M. Marsaut's lamp) an outside metallic shield be put on. This last expedient, however, is liable to the objection that the gauze may get very much heated without being noticed.

On the whole, the authors consider the improved Marsaut lamp, where there are two wire gauze chimneys and no funnel, as the safest.

Experiments with MINING EXPLOSIVES, by Dr. Klose (abstracted from Teitschrift für das Berg, Hutten und das Salinen, wesen im Preussischen Staate, Vol. XXXI., 1883, pp. 91-105) contains an account of the tests applied to explosives in the Saarbrücken Collieries. These are:—(1) THE PISTOL TRIAL, in which a small quantity of powder is exploded in a crucible, to the lid of which is attached a lever which moves a toothed wheel. On firing the powder the wheel is turned according to the strength of the powder, which is measured in degrees turned by the wheel. (2) THE ROD TRIAL, in which a rod is fastened to a piston, below which the explosive is fired, and the strength of the powder measured by the height the rod is lifted by the explosion of a weighed quantity of the explosive. In a table given by the author, compressed powder being taken at 15·3 (the square root of the height to which the rod was thrown by the powder); coarse grained powder was 13·5, mixed grained powder 13·5, and fine grained powder 12·1. (3) LEAD CYLINDER TRIALS, in which the enlargement of a space in a lead cylinder by the explosion in it of powder is the measure of the strength of the powder. A cast of the cylinder after explosion may be kept for reference. Compressed powder gave good results with this test. The lead trials proved that blasting with a space is not so efficacious as when the powder fills lightly the space allowed it. In a series of experiments the space of the cylinder was enlarged to different extents, varying from 96 to 162 times its original volume.

Dynamite was also tested, and was shown by the lead cylinder test to be sixteen times stronger than powder; but this, the author says, cannot be relied on.

Burnt lime was also tried, but in this case the greatest enlargement was only 12·3 times: and the author concludes that it would not do for the Saarbrücken Coal.

R. T. M.

THE EFFECT OF COAL DUST IN COLLIERY EXPLOSIONS.

VOL. X.; 1882, of the Transactions of the CHESTERFIELD and DERBYSHIRE INSTITUTE of Mining, Civil, and Mechanical Engineers contains an important report by a committee on Coal Dust experiments. An elaborate apparatus, which is described and figured, was constructed, in which experiments were made with various mixtures of dust and air, with and without gas, at different temperatures and velocities. Pistols were used for introducing flame into the mixtures, and different degrees of flame and shock were obtained by varying the size of charge in the pistols.

Of 180 experiments, 134 were made with dust and air only, and 46 with gas added. Three series of Tables, giving detailed particulars as to the kinds of dust used, the modes of firing the pistols, and the effect of the shots in the whole of the 180 experiments, are attached to the report.

The dusts used were from the Midland, North of England, South Lancashire, and South Wales coalfields, and were gathered from all parts of the workings, and from the shafts and pithead screens. Artificially powdered dust was also used. Microscopic examinations were made of some of the samples of dust, and the results are given.

The words "explosion" and "ignition or inflammation" being frequently used in the report, the committee, to prevent misunderstanding, define these words as

follows. "An 'explosion' is anything which causes a *sudden* increase of pressure in the surrounding air or gases from the sudden or violent expansion of any substance (gas, liquid, or solid) in their neighbourhood. 'Inflammation' is the quiet production of flame, unaccompanied by any sudden or violent change of pressure in the surrounding gases."

The more important results and conclusions which the committee arrived at are as follows.

No explosion took place when gas was not present, but inflammation or ignition occurred.

The ignited dust travelled at about the same rate as the air current.

The coal-dust flame was dark red in colour, but with gas it became of an orange tint.

The experiments seemed to point to the practicability of igniting almost any coal dust, but in some cases, in certain conditions of temperature and otherwise, never realised in actual working.

The most easily ignited dusts were those from props and pithead screens, and that specially pounded and sieved through muslin.

The heavier the charge, and the larger and sharper the flame from the pistol, and the nearer the line of discharge of the pistol to right angles with the current of air, the more readily did the dust ignite.

Dry and cold weather may be considered the most favourable for the ignition of dust.

A small explosion of fire-damp may ignite dust, and the flame be carried to other gas-laden spots, and thus a trifling explosion may lead to a serious one. This can happen only in a very dry and dusty mine.

In a current of air free from fire-damp the direct action of a blown-out shot would not ignite the most inflammable coal dust passing along the working places of a mine in its ordinary working condition.

The flame from a blown-out shot passing into a deposit of dust might ignite it, and the dust flame would have a tendency to travel with the air current, becoming (in the absence of fire-damp), less as it moved onward.

In a non-gaseous but dusty mine, the dust could, at the worst, only ignite, without explosive shock.

The committee sum up as follows—"The results obtained from the addition of very small percentages of gas, *i.e.*, from a half to three per cent. and upwards of manufactured gas, are, perhaps, chiefly instructive as showing that in a very dry dusty mine the current of ventilation may be charged with fire-damp of such a low percentage that the most careful observer would fail to detect the blue aurora indicative of fire-damp on the ordinary safety lamp. Yet it would be so charged with fire-damp that any unusual circumstance, such as a heavily charged blown-out shot, or violent concussion, might raise a cloud of dust, and render the current at once an inflammable mixture."

"Generally, the experiments may be taken to show that the purer the atmosphere of the mine, the greater the amount of dust required to make it inflammable, and conversely with regard to dust in air containing fire-damp. Also, that in no mine in its normal state, with the ventilation free from fire-damp, would an ordinary blown out shot raise sufficient dust to make the ventilating current an inflammable mixture, such as would ignite from the same shot flame, and create what might be termed, but really would not be, an explosion; the great quantity of dust required for such a current of air to become inflammable being such as to render the current an intensely black cloud surcharged with dust."

Interesting addenda to the committee's report are a report on the explosive force of coal gas and atmospheric air in different proportions; and experiments with safety lamps, by which it was proved that a Davy lamp cannot detect less than three per cent. of gas in an air current. Analyses of various coals, pit gases from different collieries, and coal gas are also given.

Not the least important part of the committee's work was the compiling of the substance of all the published reports and opinions, British and foreign, on the subject

of coal dust, and extending from the year 1812 to 1881. This is contained in an appendix occupying 189 pp.

In the discussion on the report, so ar as published, opinions were very generally expressed corroborative of those given by the committee, and later contributions to the literature on the subject were handed in by several members.

The discussion has been adjourned until after the issue of the report by the Royal Commission on Accidents in Mines, which is expected to set at rest some points in connection with this important subject, on which there are still differences of opinion.

J. B.

"On WATER-GAUGE BAROMETER, and OTHER OBSERVATIONS, taken at "SEAHAM COLLIERY during the time the Maudlin Seam was sealed up," by V. W. Corbett.—Trans. of NORTH of ENGLAND INSTITUTE. of M. & M. Engineers, part V. vol. XXXII.

With the aid of a general plan and section of the seams, the author briefly and clearly describes the position of the different shafts and workings at Seaham Colliery at the time of the explosion, on 8th Sept., 1880. As a large fire was discovered to exist in the Maudlin Seam, it became necessary to close up these workings by means of brick stoppings in the intake and return air courses; therefore this seam might then be considered as hermetically sealed. Half-inch iron pipes were inserted through two stoppings in the intake roads, and two in the return roads, to which water-gauges were attached. Readings of each of these four water-gauges and also of barometers placed at Nos. 2 and 3 stoppings and on the surface, and of thermometers at Nos. 1, 2, and 3 stoppings and on the surface, were taken every hour. The force and direction of the wind were also recorded by a self-registering instrument placed at Seaham Harbour by the Meteorological Council.

In addition to these observations, a "Gas-Check" was taken in another part of the pit, about a mile from the stoppings, and in the Hutton seam. A gallery, about fifty yards long, leading from the return air-course to the goaf edge, was kept open; and into this a man went every hour, and noted the exact distance from the waste at which gas was first observed in his lamp.

All these various readings are very minutely shown on 71 carefully drawn diagrams, giving the different indications for every hour, from 22nd November, 1880, up to and including 23rd June, 1881. Four comparisons of these indications are given, as between water-gauge and barometer: water-gauge and gas-check (two), and barometer and gas-check; and three instances are taken in each case of the most clearly defined fluctuations of pressure.

In the first comparison, between No. 3 water-gauge and No. 3 barometer, taking it over the three instances particularly alluded to, the barometer was found to indicate the changes of pressure at intervals varying from 4 to 48 hours *after* the water-gauge; and at times even to give no signs of changes, which considerably affected the water-gauge. "It is apparent by the water-gauge diagram that fluctuations of gases in col-"liery workings must be occurring almost every hour. These frequent fluctuations seem "to be clearly defined by the water-gauge whenever they take place; but they are not "correspondingly recognised by the barometer, and it appears that the barometer only "recognises what may be termed general or clearly defined great fluctuations, and even "then very slowly."

In the second and third comparisons, between water-gauges Nos. 2 and 3 and the gas-check, the indications were found practically to correspond. With an inward pressure according to the water-gauge of ·7 inch there was an absence of gas; but with an outward pressure from this reading, gas was given off, and to be found in the gas-check.

The fourth comparison, between the barometer and the gas-check, shows very great

variation in the readings, and indicates clearly the unreliableness of the barometer, gas being given off at the gas-check on several occasions of which the barometer gave no indication.

To quote from the author's concluding remarks—"One lesson suggested by the foregoing water-gauge, barometer, and gas-check readings is, that as an instrument for the use of all connected with colliery operations, the water-gauge may be found to be preferable to the barometer, and that if a water-gauge is connected with a sealed-up working, its readings indicate nearly accurately the giving off or otherwise of gas in a colliery, which the barometer fails to do."

In the discussion which followed the reading of the paper considerable allusion was made to a paper by Mr Lindsay Wood on "Pressure of Gas in the Solid Coal," pp. 163 to 260, Vol. XXX., and to the remarks on the same by Mr E. Mallard, translated in part II., Vol. XXXII. of the Transactions of the North of England Institute.

"The STRUCTURE of the CUMBERLAND COALFIELD," by J. D. Kendall, C.E., F.G.S., NORTH of ENGLAND INSTITUTE of M. & M. Engineers, Part V., Vol. XXXII.

This paper contains a very complete and detailed description of the Cumberland Coalfield, under the headings—"Position and Extent," "Relation to other formation," "Stratigraphical conformation," "Thickness of Strata," "Coal Seams," "Faults," "Dip of Strata," "Effects of faulting, tilting, and denudation," and "Sub-Permian, and submarine extension." Section of strata passed through in a number of pits in various parts of the field are given in the letter-press, as well as in drawings, and also a map of the field, and several cross sections.

"The DANGER of SPARKS produced from PRICKERS and STEMMERS used for BLASTING PURPOSES in Coal Mines, and Sparks otherwise produced," by Henry Lawrence.—Transactions of NORTH of ENGLAND INSTITUTE of M. & M. Engineers, Part I, Vol. XXXIII.

The author's attention having been called to a case where a shot had exploded, apparently from a spark caused by a brass stemmer used in stemming, he found upon trial that the stemmer in question, when struck upon a stone slab, produced a spark at every blow. He afterwards tried one made of copper, and also tried ingot copper and a copper bolt, but with the same results. He then made experiments for the purpose of discovering a mixture of metal from which it would be impossible to produce sparks by impact; and in this he has been successful. He quotes a remark made by Mr Henry Hall, H. M. Inspector of Mines, in his last annual report, as to the danger of sparks arising from the use of copper stemmers, and recommending wooden stemmers; but Mr Lawrence is of opinion that these would not stand the hard usage to which they would be subjected.

With regard to "Sparks otherwise produced," the author instances a case where compressed air locomotives were used, with iron wheels, which threw out long streams of sparks when the wheels slipped. He made trials with tyres made of various mixtures of metals, and at last fixed upon that from which the sparkless prickers and stemmers are made. As to the question whether sparks were dangerous in coal mines, a communication was read from Mr Sawyer, Assistant Inspector of Mines, relating an instance where an explosion of gas was caused by a spark from a pick used in ripping down a piece of hard roof.

A discussion at some length followed, when Mr Lawrence explained that the composition he had discovered was very nearly as hard as copper. The best test of the material he considered, was on the locomotive wheels. The tyres were put on, and the engine partially propped up and fixed, and the wheels were run at a speed of 300 or 400 revolutions a minute, without giving out a single spark, while under the same conditions a long stream of sparks was given off by copper tyres.

H. R. M.

[ADVERTISEMENT].

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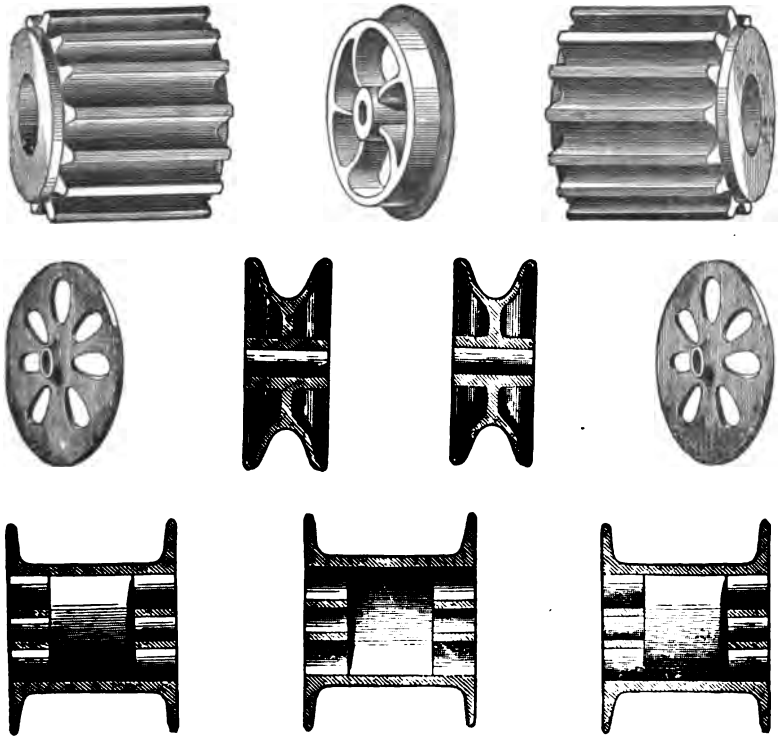

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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 31st JANUARY, 1884,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

JAMES S. DIXON, Esq., Vice-President, in the Chair.

Upwards of fifty members were present.

The Minutes of the last General Meeting were read by the Secretary and confirmed.

The following gentlemen, who had been duly nominated at a meeting of Council, were elected by ballot, and admitted as Ordinary Members :—

GEORGE BEILBY, The Birches, Mid-Calder.
ROBERT L. GALLOWAY, 98 West George Street, Glasgow.

DISCUSSION OF MR BEILBY'S PAPER ON YOUNG AND BEILBY'S PROCESS FOR THE TREATMENT OF COAL.

The CHAIRMAN having called on Mr Beilby,

Mr BEILBY said—Mr Rowan refers (p. 254) to the relation of ammonia to percentage of coke. The best reply to his question is found in the results of the last few weeks' work of the coal retorts at Oakbank. The small bench of retorts (described p. 169) is divided into two sets of six retorts each, each set having separate mains, condensers and water tanks. Set No. 1 has been worked with steam alone, about one-half of the fixed carbon of the dross being consumed by the steam. The cinders drawn

from the retorts and charged into the gas producer amount to 33 per cent. on the dross. The yield of sulphate of ammonia obtained from the dross worked in this set has averaged about 50 lbs. per ton for the months of December and January. The exact yield for seven days ending on Saturday last, the 26th January, was 52·75 lbs. per ton. Set No. 2 has been worked with a mixture of steam and air, nearly the whole of the fixed carbon of the dross being consumed, the cinder and ash drawn from the retorts amounting to 18 per cent. on the dross. The yield of sulphate of ammonia obtained from the dross worked in this set has averaged 90 lbs. per ton. The exact yield for seven days ending 26th January was 106·25 lbs. It will be borne in mind, in considering these results, that the excessively stormy weather of the last two or three months has made it very difficult to maintain the high temperatures necessary for the successful working of these retorts. The actual yields have not suffered so much as one would have feared; but the through-put of dross has suffered severely owing to the impossibility of maintaining anything more than a dull red heat on the upper, or coking part, of the retort. This has been the greatest difficulty we have had to encounter, but steps are at present being taken to remedy the defect. The retorts have supplied gas for firing two sets of shale retorts, distilling 24 tons of shale per day. The steam used in the process has been practically the same as was indicated in tables VI. and IX.—the excess on No. 1 set being 232 gallons, and on No. 2, 360 gallons. The dross used throughout has been the same; and an analysis shows that it contains 1·56 per cent. of nitrogen, equal to 164·6 lbs. of sulphate of ammonia per ton.

Mr Henry Aitken sets out by informing us that he is only going to correct certain errors in the preface to the paper. Having put himself in this position, one would naturally have expected him to oppose my clear (but erroneous) statements by equally clear and well substantiated counter statements. But has Mr Aitken done this? The first point specially noticed is the general statement, that in the destructive distillation of minerals as ordinarily practised, whether at low, high, or intermediate temperatures, only $\frac{1}{5}$ to $\frac{1}{10}$ of the total nitrogen is obtained as ammonia. Mr Aitken meets this very definite state-

ment by an expression of opinion and a reference to results which he says have been got from blast furnaces. It is worth while to examine this matter a little more closely. Scotch cannels contain from 1·5 to 2·2 per cent. of nitrogen, equal to from 157 to 232 lbs. of sulphate of ammonia per ton. Do any gas companies get more than 20 to 25 lbs. of sulphate of ammonia per ton from these cannels? This would be $\frac{1}{6}$ to $\frac{1}{9}$ of the total nitrogen. English coals, such as are used by English gas companies, contain a similar percentage of nitrogen; and the yield in well-handled gas works rarely, if ever, exceeds 30 lbs. of sulphate per ton, say $\frac{1}{5}$ to $\frac{1}{8}$ of the total nitrogen. In coking coal by the 'Simon-Carves' process the yield of ammonia does not exceed, and, probably, hardly equals, that obtained in gas works. In coking by the 'Jameson' system the yield of ammonia is placed by Mr Jameson himself [Inst. of Mechanical Engineers, April, 1883] at 10 lbs. of sulphate per ton, say $\frac{1}{12}$ to $\frac{1}{20}$ of the total nitrogen. In coking by Mr Henry Aitken's system, he states that he obtains 5½ lbs. of sulphate of ammonia per ton, or say $\frac{1}{20}$ to $\frac{1}{40}$ of the total nitrogen. In blast furnaces, according to Mr Aitken, 32 lbs. of sulphate of ammonia is obtained from every ton of coal; equal, at the before-mentioned percentages, to $\frac{1}{5}$ to $\frac{1}{7}$ of the total nitrogen. These figures, I think, substantiate my statement that only $\frac{1}{5}$ to $\frac{1}{10}$ of the nitrogen of minerals has been obtained by the methods of destructive distillation.

The next statement (foot of p. 255) Mr Aitken himself confirms. In the passages quoted (p. 256), Mr Aitken very properly complains of a want of clearness. What I wished to explain was, that it is necessarily the cokemaker's object to obtain as large a percentage as possible of the carbon of the coal in the form of *fixed* carbon; and that this was to be accomplished by allowing the volatile products to be robbed of their carbon by the red-hot coke. These volatile products must thereafter be impoverished. I do not for a moment question Mr Aitken's superior knowledge and experience on the subject of coal coking as it is practically carried out; and any opinions of mine on the subject I wish to advance with proper modesty.

Now, with regard to the whole history of what has been done

by original workers in the utilization of by-products from coke ovens and blast furnaces, I believed that once for all I had rid myself of all possible accusations of doing more or less than justice to anyone by my remark at the close of *Sec. b*, p. 161. As far as the Messrs Bairds' results have been published, they are as open to the public as they are to me; private sources of information I have none; and I therefore adhere to my remark, and shall suspend my individual judgment until all the facts and figures are before me.

The opposed opinions of two of my critics, Mr Prentice and Mr Aitken, on the value of tars other than those made in gas works, may be held to justify my own intermediate position.

The CHAIRMAN, in closing the discussion, proposed a vote of thanks to Mr Beilby, which was heartily accorded.

DISCUSSION OF THE COMMITTEE'S REPORT ON MR BALLARDIE'S SAFETY LAMP.

Mr BALLARDIE, on the invitation of the Chairman, said—On page 269 your committee state that the oil vessel of this lamp holds 1½ gills of oil, and that it burns for 30 hours without requiring any attention. You may suppose that double that quantity of oil (3 gills) will burn double the time, or 60 hours, which is a full working week, at a cost of three farthings; and this, with a light-giving power equal to from 1½ to 1¾ of standard candle.

On comparing this lamp with the open light, the lamp gives a better light by ·4 than the open light, and works at a saving of sixpence half-penny per week on each light.

The lamp as given to your committee has been found by them to be too sensitive to currents of air. This very sensitive quality was not observed in carrying the lamp through the workings of an ordinary mine, or it would have been altered before handing the lamp to your committee. The alteration now made is to introduce a small metallic disc into the bottom chamber, which acts

as a wind buffer, and also to lengthen the funnel and give it a little more taper. The result of this alteration is to make the lamp such that it can be used with as much freedom as other lamps when in currents of air.

Next noticed in the report is the behaviour of the lamp in gas. No doubt the trials made were all of a good practical kind, and go far to prove the value of the lamp when gas is met with. In the first trial it may safely be presumed that the proportion of gas surrounding the lamp did not exceed 5 or 6 per cent. Had it been greater, an explosion in the bottom chamber could not have been prevented, and as a consequence the flame of the lamp would have been extinguished. For the second trial, the gas present must have been above 7 per cent., as the light was put out, undoubtedly, by the explosion in the bottom chamber. For the third trial, the flame elongated, but the lamp was held in the gas till the explosive mixture entered the lamp which extinguished the light. But the gas continued to burn in the lower chamber, proving that it was in a mixture of above 10 per cent. The shutter, or cover, was not used to put this out, but the lamp was withdrawn. In the next trial the lamp was extinguished at once, same as in the second trial.

Since the report was read, two series of trials have been made with various lamps in an explosive current, in an apparatus constructed for the purpose. The lamps tried were the Davy, Clanny, Mueseler, Williamson, and Ballardie. The first two behaved in such a way that they could not be considered safety lamps. The others were extinguished each time. The notes of the first series of trials state that the Ballardie lamp is very sensitive in gas. I was present during the second series of trials, and found the result to be exactly as reported in the first series. Throughout a great variety of trials that have been made with this lamp there has been no instance of gas being ignited outside of the lamp.

In the first paragraph of the conclusions arrived at by your committee, it is stated that this lamp is too easily affected by air currents. This objection, no doubt has been fully met by the introduction of the metal disc and the alteration of the funnel already described.

As to the second paragraph, I would prefer making no remark. But it seems strange that such a conclusion should be arrived at by gentlemen who know that in this immediate neighbourhood there are hundreds, perhaps thousands, of lamps of the gauze type daily in use where the presence of gas is to be apprehended; and that style of lamp is known to be unsafe in explosive currents, and still a doubt is expressed about the lamp now before you, which has been tested and found to be much superior in every point.

Mr DRINNAN said there was one objection that he considered very serious, which the committee had taken to this lamp, and which Mr Ballardie had not taken notice of, viz., that the gauze had got saturated with oil. They could scarcely conceive a more dangerous state of things; for, if by any means the flame got hold of the oil, the gauze would be sure to burn, and nobody could foresee what consequences might result. It would be well if Mr Ballardie could explain whether the defect by the leakage of the oil had been remedied, or if it were possible to remedy it.

Mr BALLARDIE said it was a mechanical fault merely requiring the tube to be made a little tighter.

Mr R. T. MOORE said he did not know whether it was exactly a part of the discussion, but he would like to know of any experiments as to whether flame would really pass through gauze when wet with oil. He had tried this in a rough way, by throwing some naphtha on the gauze of a lamp; and he did not find the flame inside to light the naphtha on the outside.

Mr DRINNAN said he had seen, when an ordinary Davy lamp got saturated with oil (through its having been tilted to one side and the oil escaping), for about an inch or so up; that the oil got ignited, and the flame surrounded the whole of the outside of the lamp. Where he had been in England, the Clanny was mostly in use; but the greatest care was always taken not to allow any oil or dirt of any kind to get about them, because of the danger.

Mr ROWAN—Do I understand the light was on both sides?

Mr DRINNAN—Right through.

Mr ROWAN—And the flame passed through from one surface to the other?

Mr DRINNAN—It was quite saturated with oil.

The CHAIRMAN—The gauze would require to be red hot.

Mr ROWAN said it was a common experiment, in showing the power of wire gauze to extinguish flame, to pour flaming spirits of wine upon it; when the liquid passes through, leaving the flame on the other side of the gauze.

Mr GILCHRIST said that the question had been taken up and discussed by the committee, and on it being tested they found they could not pass the flame through the gauze.

Mr DRINNAN explained he could not be positive at the present moment whether or not the gauze was on the lamp when it ignited. All he remembered was that the gauze was so saturated with oil that it flamed all round.

Mr TELFER—What class of oil was used in the lamp?

Mr DRINNAN—A sweet, vegetable oil.

Mr RALPH MOORE said he was quite of Mr Drinnan's opinion, that it would not be safe to try such an experiment in a mine where there was gas; but he recollected trying a common Scotch lamp. He had some doubts as to the safety of the use of naphtha, which was very extensively used for safety lamps in their pits. He took a common Scotch gauze lamp saturated with naphtha, and kept common gas burning in it for ten minutes, but with no current of air, and while the gauze was heated to a dull redness, there was no explosion nor light outside. But, had there been a strong current of air, he would be inclined to think there would have been a different result; because then the flame, on the heating of the wire, would have been carried further through. The heat was merely in the inside. Speaking of Mr Ballardie's lamp, he thought the committee appeared to have taken considerable pains, and acted with a determination to do Mr Ballardie justice in their remarks. The lamp seemed to him to be too large. It was unhandy; and compared with such lamps as they saw working at, say, the Clyde Coal Company's works, was more unwieldy. He did not see anything in the principle to hinder it being made smaller, and he was afraid they would not readily get workmen to use it in its present state. There was no doubt whatever that it gave a better light; and its behaviour in gas—well, he thought probably it was like lamps in general. He looked forward himself, not to great improvements in lamps which were fed with the air of the mine; but to the electric

light,—such as the Swan lights,—being very largely used in mines; and he had no doubt that by and by they might come to have them in use at the face. He did not see anything against them. At present, they were not quite at that stage, but he thought they were not very far from it. His idea had always been that they should endeavour to reduce the cost of the Swan lights. Mr Watson at Earnock had shewn a very good example in making trial of the electric light; but until they had the lamps much cheaper he did not think the electric light would do yet. Still, that, it seemed to him, was the direction they should look for improvements. There were a great many variations in safety, talking of the safety lamp,—from the naked light up to the most refined lamp; but each of the lamps was suitable for the work it was put to do in most cases. They found that in the aggregate, more people were killed and burned in small explosions where the current had nothing to do with it than in larger explosions; and he did not see that the lamps they had in use were not quite sufficient to meet with the evil for which they were used.

The CHAIRMAN proposed a vote of thanks to Mr Ballardie for bringing his lamp before them; and to the committee for the trouble taken in making the experiments. The conclusions come to showed that the lamp wanted some of the vital qualities of a safety lamp; but, on the other hand, it was a lamp that gave an excellent light; and he thought the remarks of the committee might lead Mr Ballardie to still further improve it. He asked them to encourage him to go on and perfect it. (Applause.)

ON AN IMPROVED ARRANGEMENT FOR WORKING UNDERGROUND PUMPS BY MEANS OF HYDRAULIC PRESSURE, BY MR ROBERT THOS. MOORE, B.Sc. CIVIL AND MINING ENGINEER, GLASGOW.

The problem of how best to drain our mines is one of the greatest interest to an Institution such as this; and the appointment of a committee to consider the subject, shews that the Council fully appreciate it. As a contribution, the writer

ventures to describe a new method of pumping water from mines, whereby a steam engine, placed on the surface, can give motion to a pump placed at any distance from it in any direction, without pump rods of any description.

It would be easy to dilate upon the inconvenience of pump rods, and upon the expensive nature of their upkeep, and also upon the destructive and expensive nature of breakdowns, when the full power of the engine is continued without any resistance. This, however, is so well known to the members of this Institute that it is unnecessary to take up the time of the meeting discussing it.

But it may be stated that these difficulties have, in a great measure, set men thinking as to whether they could not dispense with pump rods altogether; and the direction that this so far has taken has been, to place the steam engine at the bottom of the pit or in the mine, carrying the steam from the surface; or erecting steam boilers underground. In some instances applications of hydraulic power—such as that employed by Mr Johnstone, one of our members—have been in successful operation for draining dooks, the power being obtained from the rising column of the pump, worked by the engine on the surface.

The arrangement about to be described is a form of pumping water by hydraulics. Advantage is taken of the fact that water is practically incompressible; and that if a pipe of any length is filled with water, a piston placed at one end will, if pushed forward, propel a piston placed at the other in the same direction.

If there were two pipes, and two pistons moving in opposite directions, there would thus be a reciprocating motion.

The leading ideas are:—

1. That the water confined in the pipe shall be pressed at not less than 1000 lbs per square inch, so that the plungers and pipes may be of small diameter.

2. That there shall be a connection between the two mains, to do away with shocks.

3. That the height of any lift may be 300 fathoms.

4. That while the water in the plunger may travel at any speed from 80 to 100 feet per minute, the speed of the water in the pipes may be 300 feet per minute.

These preliminary remarks prepare for the description of the system, which is the invention of Mr Joseph Moore, of San Francisco, who has appeared before this Institute. The system is suitable for all the three classes of pumps :—

1. For pumps placed at the bottom of a vertical shaft.
2. For pumps placed inside the workings.
3. For sinking pumps.

In all these cases the steam engine is placed at any convenient position on the surface.

It will be convenient, in the first place, to describe the engine, which in the drawing (Plate XIII.) is shown as a horizontal one, with the piston rod passing through each end of the cylinder, and having a plunger on each end. While this form of engine has been shown, it is evident that any form of engine can be employed which gives a reciprocating motion to the two rams; or the rams may be attached to cranks where the engine has a rotary motion and the speed is reduced by gearing.

The pump placed at the bottom of the shaft is the same as the dook pump (Plate XII). Two pump plungers, A and B, are placed horizontally, with the stuffing boxes facing each other and the usual clack pieces at each end. They draw water from the same suction and discharge it into the same rising main. They carry a crosshead C between them, and to this are fastened four power plungers, D,D, D′,D′, two on each side. These power plungers are connected to the power rams on the surface by two power pipes, E, E′, the plunger *d* being connected to the plungers D,D, and having the same area as the two, and the plunger *d′* being connected to D′,D′. When the steam piston moves from *d* to *d′*, the ram *d′* forces the water down the column of pipes E′, into the underground power plungers D′,D′, and the pump is driven from B to A. When the stroke of the engine is reversed, the water from *d* is forced down the power pipe E to the plungers D,D, and the pump moved from A to B, while the water in the plungers D′,D′ is driven back the power pipes E′ to refill the plungers *d′*. In this way the pump underground is driven backwards and forwards, following the motion of the steam-engine on the surface, the water in the power pipes never being changed.

The pressure pipes are filled with water from a cistern placed at a level above each of them, through valves G which open only inwards, and so prevent the water from flowing out.

In order to prevent shocks by the stoppage of the moving column, and any irregularity between the movement of the power plungers above and those below, the power pipes are connected, so that by opening a relief valve V (Plate XIII.), the water may pass from one column to the other. This is effected by means of the following arrangement:—The crosshead C (Plate XIII.) carries a bar D which is so fixed that at the end of the stroke it comes in contact with a small bellcrank E which opens a valve V between the two pressure pipes. The necessity for this valve and its action will readily be seen.

Thus, if the engine on the surface were about to begin a stroke from *d* to *d'* while the power rams underground were at D', the stroke in the pumps could not be made. The crosshead would open this valve and allow the water to pass through it from the pipe E to the pipe E', until the stroke was completed. The engine on the surface and the pump underground would then be in their right positions, and pumping would begin.

The pump underground may be put up vertical, or in any other position. To pump 200 gallons per minute from a depth of 130 fathoms, with a steam pressure of 40 lbs. per square inch, the steam cylinder would be 26 inches diameter, the power plungers on the surface 5 inches diameter, and 4 feet stroke. The pump underground would be 8 inches diameter and 4 feet stroke, with the power rams $3\frac{1}{2}$ inches diameter. The pressure pipes would be $2\frac{3}{4}$ inches diameter, and $\frac{1}{4}$ inch thick.

The dook pump is precisely the same as the one described, the only difference being that the water is conveyed to any required distance.

The high pressure on the pressure plunger enables a very compact arrangement to be made for dook pumping. Thus, to pump 120 gallons per minute 20 fathoms, an 8in. pump plunger, 2 feet stroke, and two $1\frac{1}{2}$in. power plungers would be required; while the power pipes would only be 1in. in diameter.

In the arrangement for sinking, the columns of pipes and the

plungers slide in wooden guides O.O in the same manner as a cage, and are lowered down as the sinking proceeds.

They are suspended by two sets of rods R of sufficient strength attached to the cross-head of a hydraulic ram, which raises or lowers the pump and pipes.

In this case, the plungers are placed vertically, and the one plunger is half the area of the other, so that the pump is double acting.

The reason for using this form of plunger is that the distance from the water to the bottom of the plunger is less than would be in any other case.

D D, D′ D′ are the power rams, and their action is the same as in the dook pump. The lower pump plunger A is 18 inches diameter. At the bottom of the plunger casing is a clack piece; below that is the suction. The plunger is hollow and has a clack inside of it.

The upper plunger B is 12·73 ins. diam., and is also hollow; and the water from the lower plunger passes up through it into the rising main. S is the stuffing box of the large plunger; T of the small one. The upper casing is connected to the rising main, and the lower casing is hung from the upper one by four bolts.

The following is the action of the pump:—When the plungers ascend, the lower plunger lifts a quantity of water represented by the diameter of 18 inches, and it passes up through the lower valve, the valve inside the plunger remaining shut. When the plungers descend, the valve at the bottom shuts, while the valve in the plunger opens, allowing the whole water from the 18-inch plunger to pass through it; but, as at the same moment the 12-inch plunger is descending out of the casing, only half of the water ascends to the surface, and the other half fills the space occupied by the 12-inch plunger. When the plunger ascends again, the 12-inch plunger discharges the water into the rising main.

Immediately above the upper barrel is an air vessel, 14 feet long, made of sheet iron. The water passes up a central pipe, which dips down from the top of the air vessel, and it is the annular space round this central pipe which forms the air space, the central pipe communicating at the top with the rising main. A

cup and small discharge pipe are provided for receiving, and at convenient intervals discharging, any sediment deposited from the ascension pipe.

The rising main is made of malleable iron, in 24 feet lengths, and having cast iron flanges rivetted to them.

The joints are spigot and faucet, and are made with a ring of gutta percha, $\frac{3}{8}$ of an inch in diameter.

The hydraulic ram is worked with a small hydraulic engine, and raises and lowers the whole column. The lever which works this engine stops the main engine on the surface and opens a valve communicating with the power pipes so as to let off the pressure due to their sliding into the sleeve pipes. The upper two lengths of the rods are provided with holes, into which a crosshead K is put for the plunger of the ram to press against.

Attached to the girder which supports the ram are two rods A.A (Plate XIV., Figs. 1 and 2) of the same strength as the main rods, carrying a crosshead B with recesses like a boring tool for catching the heads of the rods, which have a shoulder made to fit it. When the ram has run its full length, this is put under the rods, and the whole weight of the pipes, &c., rested upon it. A new length of rods is put in, and the ram is run out till it comes in contact with the crosshead. The temporary rest is then removed, and the ram is ready for further lowering.

On the top of the rising column is placed a "hogger" of sufficient length to allow the water to fall into the discharge drain for 24 feet, or any other length required; but the power pipes work in stuffing boxes, LM.

The clacks are made of hard vulcanised indiarubber (a sample of which is shewn) confined in the upper lid, and have given great satisfaction. The clack in the inside of the 18-inch plunger beats upon a face cast upon it at H (Plate XIV. fig. 4). The clack itself is the same as the lower one, but as the arrangement for changing it is somewhat peculiar, it may be well to describe it.

The smaller plunger is carried down into the middle of the larger one, as shewn in the drawing, and terminates in a recess in which works the T shaped head of the clack. When it is in operation, the lid has free room to move up and down without check. When the clack is to be shifted, the column of water is

run off, the pump raised to the top of its stroke, and the upper plunger disconnected from the lower one and suspended by two links. The lower plunger is then lowered down.

The clack lid remains hung by the T head on to the inner plunger; and, as the lower plunger descends, is left outside, when it is drawn out of the slot and renewed. The lower plunger is then raised and the two connected, the clack having then room to work as before.

The stuffing boxes of the rams are rounded at the bottom and top, as shewn in drawing (Plate XIV., fig. 3), and this has also been found to be a great advantage.

One sinking pump of this description has been at work for the last twelve months; raising 300 to 500 gallons per minute 600 feet high; and has given great satisfaction. Practically there has been no difficulty; and the thing has moved on and moves on quietly.

The advantages claimed for the system are

Its extreme simplicity; there being no valves employed, except the clacks of the pumps.

The facility with which it can be applied at any distance from the engine.

The small space which it occupies, in consequence of the high pressures used.

There is no danger of fire, nor any heat from steam pipes.

The engine on the surface can be much better looked after than if it were underground.

It can be started although covered with water; and, if it is a sinking lift, can be raised up to the surface, if necessary. As compared with an engine working with pump rods, there is the entire absence of pump rods.

The only disadvantage is the extra number of stuffing boxes, and the friction of the power rams in stuffing boxes over what would be if the piston were applied direct without the intervention of the water. From careful experiments it has been found that the friction due to the power pipes, and the power and water plungers, with properly constructed pipes and stuffing boxes, does not exceed 11%, which is much less than the friction in pump rods.

TO ILLUSTRATE Mr ROBT THOS MOORE'S PAPER.

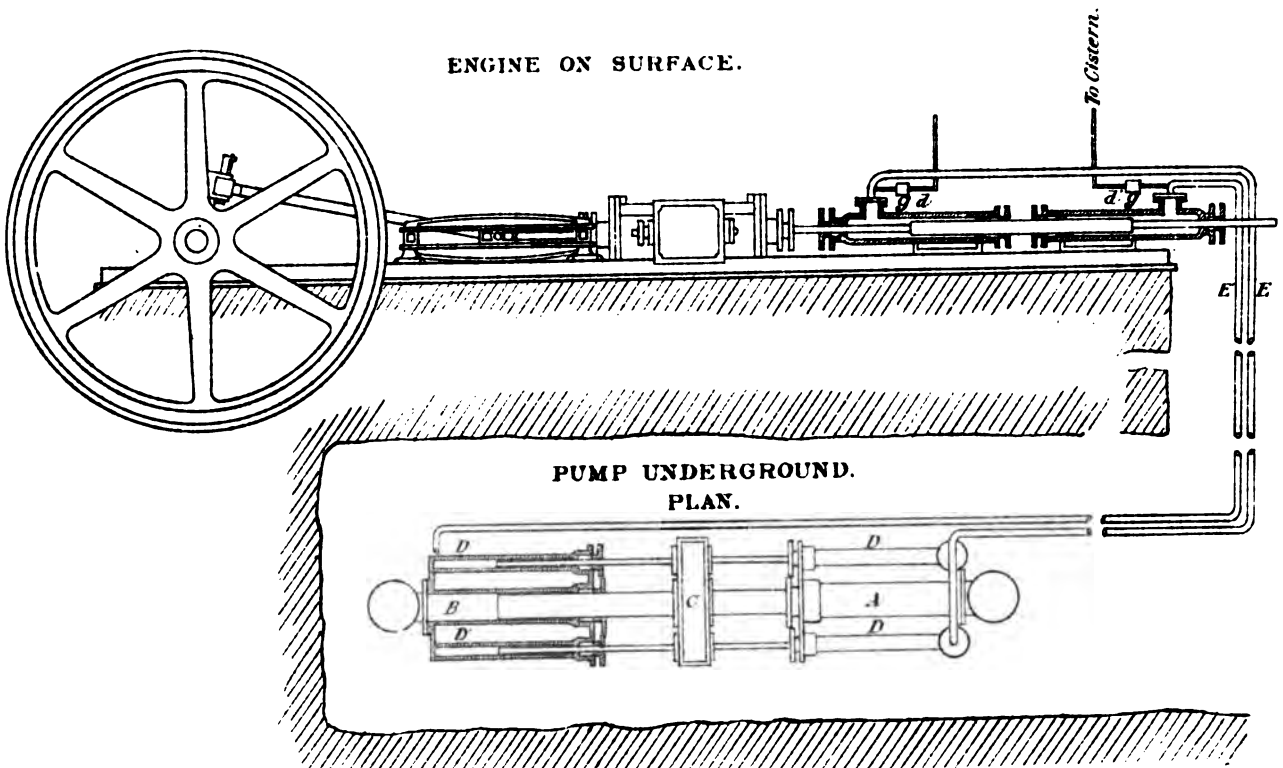


PLATE XII VOL. V
M.I.S.

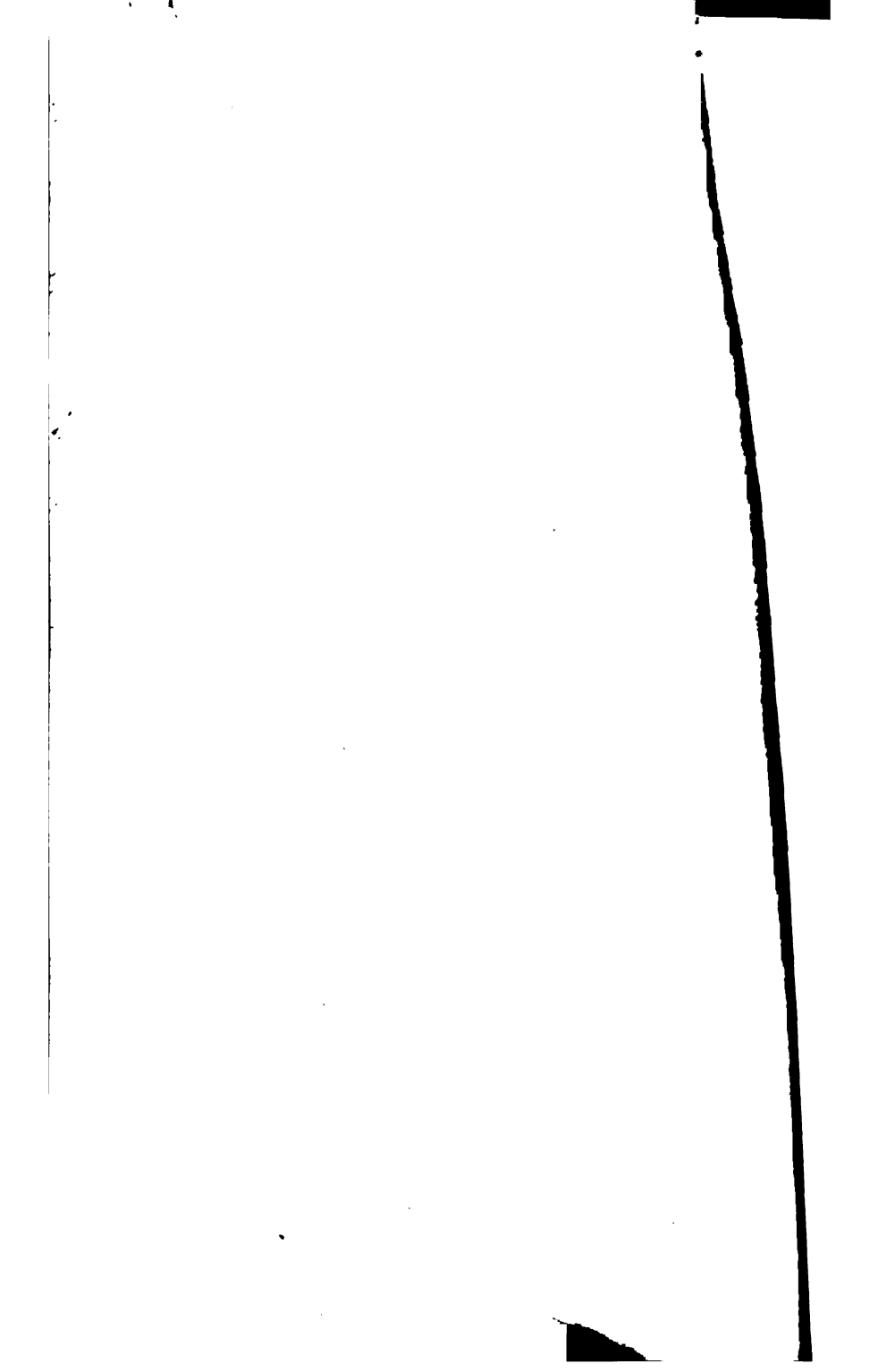
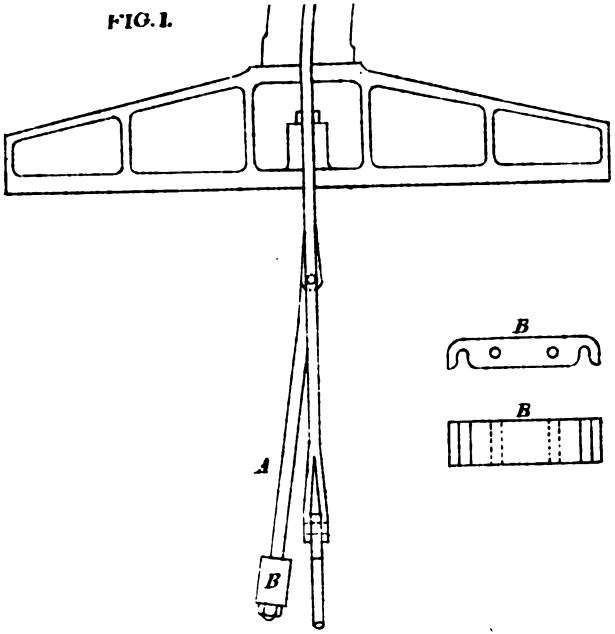
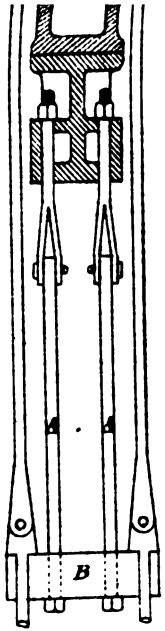


FIG. 1.





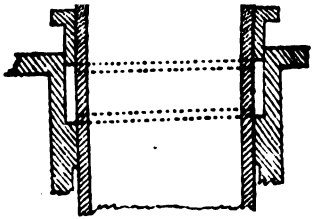
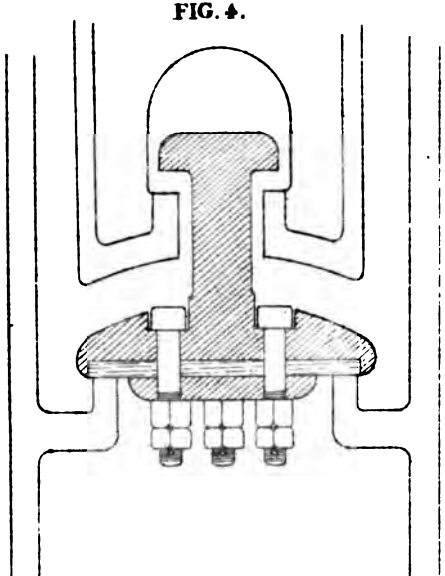


FIG. 4.



TO ILLUSTRATE Mr ROBt THOs MOORE'S PAPER.

PLATE XXXV.
M I S.

DISCUSSION.

The CHAIRMAN said if any gentleman wished any explanation they might get it that night. Otherwise, they should hold over the discussion until they had an opportunity of studying the paper. He had had the pleasure of hearing Mr Moore of California describe the system of hydraulic pumping so far as a dook and bottom of a pit were concerned, but this was the first time he had heard the sinking pump described. He had long been of opinion that the communication of power by water ought to have been applied in mining. It had long been applied at docks, and there was nothing to hinder it being applied in mines in the same way.

Mr BEILBY said, though not a miner, he had been much interested in the transference of power both electrically and otherwise. He would like if Mr Moore would give them some idea of the loss by friction of the water in the pipes. He had mentioned that the loss from friction in the plungers was 11 per cent., but he presumed the loss of power from the transference of the power through a pipe possibly 300 to 400 feet long and 3 inches in diameter must be very large. He supposed the loss, if the power were transferred by compressed air, would not be less than 50 per cent. The loss electrically would also be 50 per cent. He would like to know how the loss would compare with those others.

Mr R. T. MOORE did not know if there had been any accurate experiments for determining the average friction; but, from tables he had seen, it was shewn that the friction from the driving of water through a 3-inch pipe at a velocity of 5 feet a second was 5 per cent. of the head.

Mr BEILBY—Do I understand the loss of 11 per cent. covers this also?

Mr R. T. MOORE—Yes. There was 89 per cent. of the power put into the steam engine got out of the pumps.

Mr DRINNAN said the subject was much too complicated for him to attempt to discuss it at that meeting, having only so recently heard the paper; but he thought it would be well if Mr Moore were as well prepared at next meeting as possible with respect to the question of friction of the power pipes.

The CHAIRMAN said the paper was one of great interest, and required considerable study. If this water could be kept in the pipe without leakage, it was practically a rigid bar.

HOW TO MAKE THE MOST OF OUR COAL IN COKING IT, AND HOW BEST TO TREAT IT WHEN MAKING GAS FOR HEATING BOILERS, &c.: By Mr HENRY AITKEN.

In this paper the writer will endeavour to be as concise as possible, and will avoid entirely the history of the subject, and also all detail of the various plans which he has tried; as, although the birth of a new idea may occupy little time, the experimenting takes long, and it takes still longer to convince others that the process is worthy of adoption. The subject will be divided into three heads, viz. :—

1st.—The making of coke in order to obtain the highest yield and the best quality of coke, at the same time securing the ammonia, oil, gas, and heat.

2d.—The making of coke, in order to get oil and ammonia with a large yield of gas and a smaller yield of coke, and that not of the best quality.

3d.—The making of gas to be used in raising steam and in heating or puddling furnaces, and obtaining at the same time oil, or tar, ammonia, but no coke.

First.—The Making of Coke in order to get the Highest Yield and Quality of Coke, at the same time securing Ammonia, Oil, Gas, and Heat.

Figures 1 and 2 show a beehive oven, altered to the system which the writer considers to be the best possible where the above objects are desired. In order to carry on the coking in this oven, while at the same time taking off the oils and ammoniacal water, three flues, about four inches square, G G G, are made in the bottom of the oven, and these are covered with tiles having perforations about $\frac{1}{4}$ inch diameter on the top, and 1 inch diameter on the under side; or bars of iron, wedge shape, with spaces between, may be used as covers. These three flues meet in one near the door, and into this flue the pipe H is inserted, which is connected to the condensers, washers, and absorbers.

These may be of any shape, such as those used at gas and oil works: but it is necessary that a mechanical exhauster or steam jet should be in connection with them in order to assist in drawing the gases from the oven.

The oven is worked in the following manner:—The oven having been filled with coal is kindled, and the blast is applied through the pipe C; and after a considerable heat has been raised (which generally takes from two to three hours), the top exit from the oven is partly closed, so as to bring a pressure of about two-tenths of an inch on to the gases in the top portion of the oven. The connection to the condensers is then opened, so as to take off the gas from the flues before mentioned. The exhauster is put into operation, and brings a partial exhaust on to the bottom of the oven of a little over two-tenths of an inch of water: and this state of matters is continued until the oven has worked itself off.

The gases, after being condensed, are deprived of their ammonia and oil, and are forced into the top portion of the oven, through the pipe F, where they meet the air from the pipe C, and produce a very intense heat, coking the coal with great rapidity. In the Slamannan district the usual time required for coking a 3 ton 10 cwt. to 3 ton 15 cwt. charge of coal is about three days. By adopting the above process the time occupied, using the same coal, is from 38 to 43 hours, so that by this process each oven cokes nearly twice as much coal as the ordinary beehive oven.

The yield of oil obtained in this way of working was over twelve gallons per ton of coal; sp. gr. from ·925 to 1000; but the yield of oil depends on the kind of coal used. The exact composition of this oil has not yet been determined. It has been purified and made into burning oil, lubricating oil, and paraffin scale. The burning and lubricating oils are not of first-rate quality, and cannot compete with shale oils. The paraffin scale, however, is of good quality, having a high melting point.

The most suitable purpose to which these oils can be applied is the making of gas, when it is desired to increase the illuminating power; but when fractionated, the lighter portions can be used for burning in torch lamps, and the heavier for creosoting

timber. The loss in distillation is very small, as low as 1 per cent. No doubt, if all the coke required in the country were made in this way, the market for these articles would soon be glutted; but there is another purpose for which they are well suited, that, is raising steam; and the writer ventures to predict that it will not be long before some of the ocean steamers of this country get their heat from oil. When we consider that the average of our coal produces about 14,000 units of heat, and that such oil as this contains about 28,000 units, we can easily see how such a material will come to be preferred to coal, especially as the labour of stoking would also be saved. No firemen to keep on board ship; greater rapidity filling bunkers; one fourth less space required for the storage of a ton of oil compared with a ton of coal: these are important points; besides, every ton of oil will raise more steam than two tons of coal, for the heat units in the oil are twice what are in coal. But this does not represent the full advantage that will be got, as the supply of oil could be perfectly regulated, and the gases consumed, which cannot well be done in coal firing.

As regards the yield of ammonia, there are no figures to shew; but as the oven was formerly worked by allowing about one half of the gases to ascend direct to the top of the oven, and be there burned, only taking down about one half of them, and in this way of working a quantity equal to 5½lbs. sulphate per ton of coal was got, and that too without scrubbing or washing the gases, there are grounds for the confident belief that between 20 and 25 lbs. of sulphate per ton of coal was got from coal containing the usual 1½ per cent. of nitrogen that is found in most Scotch coals. An eminent chemist, who had just concluded a series of experiments to ascertain the amount of ammonia in certain coals, informed the writer that if the gases from an ordinary retort were allowed to pass away from the condenser pipe without being scrubbed, they would carry away as nearly as possible one half of the ammonia with them.

The yield of coke is 1 or 2 per cent. less than that got from a retort. It may be here remarked that the yield of coke from ordinary beehive ovens at Slamannan is from 50 to 52 per cent;

while by this process 65 per cent. was got; shewing a difference of 25 per cent. of coke in favour of this process. The quality of coke made was of the finest, and very much superior to that manufactured in the ordinary way.

There is ample heat in the gases, after they leave the ovens, to raise all the steam required for the blower and exhauster; and a portion of the gases could be spared and consumed for other purposes. The illuminating power of the gases is not great. It was not tested with a photometer; but the appearance of the flame, which varied according to the state of the oven, indicated from 6 to 12 candles. Almost any kind of oven can be altered to this system. Figs. 3, 4, and 5 shew a rectangular oven so altered.

The profit and loss of this process may be stated thus. Say 10,000 tons of coal are coked, and presume that one oven by the new process will do as much work as two of the ordinary beehive ovens, and that the additional cost of blower, exhauster, condensers, &c. (so far as estimates have been made, the costs seem equal), for each oven in the new process is the same as the cost of an ordinary coke oven, so that the capital expended for the amount of coal coked is the same in both cases. The old process gives a yield of 52 per cent. of coke: 10,000 tons coal = 5,200 tons coke.

By this process 10,000 tons coal will give, at 65 per cent., 6,500 tons coke; difference of 1,300 tons coke at, say 10s.,	£650
12 Gallons oil per ton, 120,000 say at 1d. per gallon, - -	500
Say only 12lbs. sulphate of ammonia per ton, at 1d. per lb. profit, - - - - - - - - - - - -	500
	£1650

Four men should be able to attend to the blower and exhausters, and the regulating of 50 ovens. These 50 ovens should make into coke 10,000 tons coal in 125 days; so that there falls to be deducted from this £1650 a sum of from £80 to £100 for wages; and, say £10 for oil and furnishings for engines.

The coke made by this process is of much better quality than that made in the ordinary beehive oven, but there is not anything added on that account, although it would be quite justi-

fiable to do so. It is of advantage, in making coke in any kind of oven, when coals are of a very dry or non-coking or gendering description, to mix pitch or tar with them before they are put into the oven, and among the samples produced is some of the coke so made in the oven described.

Secondly.—THE MAKING OF COKE IN ORDER TO GET OIL AND AMMONIA WITH A LARGE YIELD OF GAS, HAVING THEREBY A SMALLER YIELD OF COKE AND THAT NOT OF THE BEST QUALITY.

Figures 3, 4, and 5 show an apparatus for accomplishing this. The chamber A is partly filled with coal and kindled on the top. So soon as it has kindled all over, air is forced in through the pipes Z, and the products of combustion and distillation are forced down through the coal into the flue D, which is covered with perforated bricks, or iron bars set apart. The gases are carried off by the pipe E, which connects with condensers, scrubbers, and absorbers—the gas being freed from its ammonia by water, and the hydro-carbons being absorbed by passing the gas through cold tar. So soon as all the volatile matter is drawn out, the air is shut off and the coke drawn, or watered out and drawn.

The yield of coke got in this manner of working is from 40 to 48 per cent. from coal giving in a retort 60 per cent.; the quality not first-rate, but good enough for smithy purposes and for use in blast furnaces of moderate height. The quality of the coke depends of course very much on the kind of coal used. The apparatus with which the trials of this process were made was only provided with a condenser, and without washer or absorber; so that neither the full amount of oil nor ammonia was got; but the yield of both was good considering these circumstances, viz., about forty gallons water per ton giving equal to 16 lbs. of sulphate of ammonia, and twelve gallons oil per ton of coal. If the same rule is applied, to which reference is made in a previous part of this paper, the amount of ammonia to be got in this manner of working will be over 30 lbs. of sulphate per ton of dross or small coal. The analysis of this oil is as follows:—

SAMPLE OIL.

1st.—1·43 per cent. distilled off specific gravity, ·876 at 60° Fsh.
Do. re-distilled B.P., 130° C.
Yields ¼ per cent. at 140° C.
5 per cent. at 150° C.
20 per cent. at 160° C,
160° C distillate re-distilled = 0·286 per cent. of original quantity sp. gr. ·812 at 60° Fsh.
B.P. 100° C.
Yields 10 per cent. at 120° C.
30 per cent. at 130° C.
65 per cent. at 140° C.
90 per cent. at 160° C.
2nd.— 5·72 per cent. sp. gr. ·900 re-distilled B.P. 162° C., 10 per cent. 180° C.
3rd.—15·00 per cent. sp. gr. ·934.
4th.—15·00 per cent. sp. gr. ·948.
5th.— 8·00 per cent. sp. gr. ·955 containing about 3 per cent. paraffin scale.

45·15
54·85 Coke and loss.

100·00.

The examination of this oil proves that it belongs to the series between paraffin crude shale oil and coal tar. The only product in it that is identical with a product derived from either of the others is the paraffin scale; but as the latter is found in minute quantities in many Scotch coal tars, there is nothing out of the way in this further than that it is present in a larger proportion. A portion of the 0·286 distillate refined is produced. It is exactly the sp. gr. of No. 1 Paraffin Oil, but is of a different nature altogether, being too volatile. If it were ·862° sp. gr. in place of ·812° and the same volatility, it would consist of a mixture of toluole and solvent naphtha. It dissolves india-rubber and gutta-percha with great rapidity.

Nos. 2, 3, and 4 distillates might be used for creosoting wood. The sp. gr. of these is too high and the body too thin, with smell too strong to make good lubricating oils to compete with shale crude oils.

The fifth 8 per cent., after extraction of paraffin scale, might make an indifferent grease oil. These oils, 2, 3, and 4, are worth 2d per gallon, and if 6 per cent. of oil is left in the pitch, it is worth 25s per ton.

The amount of gas got was not measured, but it is estimated to amount per ton of coal to 7000 feet hydro-carbon gases and 12,000 feet carbonic oxide gas. When it is desired to make the liquid hydro-carbon products of a tarry nature, one charge of coal is coked, and when the coke is still hot, another charge of coal is put on the top, and the process is carried on as before. This may be repeated as often as desired till the chamber is full. When it is desired to produce hydro-carbon oils as near as possible to the oil-work series, there is forced in with the air on the top a certain quantity of steam or water, and by this means more ammonia is got; and if it is wished to produce even better results in this direction, the products of one oven are drawn or forced through the flue C, as shewn in dotted lines on plan, Fig. 3, and down through the coal in another oven.

Thirdly.—THE MAKING OF GAS TO BE USED IN RAISING STEAM, AND IN HEATING OR PUDDLING FURNACES, AND OBTAINING AT THE SAME TIME OIL, OR TAR, AMMONIA, AND NO COKE.

The first apparatus to which reference will be made, is the same as that last described and shewn on figures 3, 4, and 5, —the only difference being that the flue D is covered with iron bars with spaces between them; and it is made larger, so as to admit of being more easily cleaned out. The process is carried on in the same way as last mentioned, with this difference, that the air is applied till all the coke is consumed, steam also being put in with the air. The gases are condensed and treated as in the other process. So soon as the coke is nearly all consumed, the air is shut off and the ash withdrawn, and the chamber refilled with coal. The oils got in this manner of working are much the same as those obtained by the last mentioned method of working. The ammonia should be considerably increased, but this has not been determined.

In the manner of working, the whole top surface of the coal is exposed to the air, and so the combustion is slow. No clinker was formed with any of the coals tried. The steam added also prevents the formation of clinker when it is desired to carry on the making of gas without interruption for cleaning. Flues are put between the producers to carry the products of combustion over, or to,

the top of the coal in the next producer; and so soon as the coal is nearly all consumed in the first chamber, these flues are opened and the gas passed through the material in the next producer. The air is applied till all the carbonaceous matter is consumed in the first producer, when it is put directly on to the second producer, and so on. In this manner of working, gas is produced continuously. Many have objected to the system of making gas in a separate chamber from that in which it is to be consumed. They allege that the loss of heat is great in respect that the heat developed in making the carbonic oxide is lost; and the heat units developed in making carbonic oxide amount to 4452 out of a total of 14,544 heat units when the carbon is all reduced to carbonic acid. But these gentlemen forget that the 4452 units of heat developed in making carbonic oxide are the heat units from dry carbon, and not the heat units developed in making carbonic oxide from common coal. The writer has not been able to ascertain how many heat units will be developed in making coal into carbonic oxide; and it will not be an easy matter to arrive at this: no doubt they will vary with the different kinds of coal. From experiments it is perfectly clear that the greater portion of the heat is utilised in distilling the coal and driving out the hydro-carbons and water.

Others have objected to the use of gases from which hydro-carbons have been partly taken, on the ground that the loss of these would reduce the heating power of the gases to a very great extent; but these gentlemen have failed to keep in mind that if so much of the hydro-carbons are taken away, so too is the aqueous vapour; and as all the hydro-carbons taken out only amount to, say, 12 gallons, or 120 lbs., and the aqueous vapour amounts in many cases to 336 lbs. per ton of coal, it is quite clear that these dried gases will burn better and do more work, and that in a shorter time than the aqueous-burdened gases. This has been the writer's experience, and it is now the experience of others.

In order to meet the objection to the loss of heat in making carbonic oxide, and trouble with clinker in the producer, the Boiler Producer, Fig. 6, was designed. Here the initial heat is absorbed by the boiler; and any heat in the escaping gases

is taken up by the feed water for the boiler passing through a series of pipes placed in the "downcomer," N on Fig. 6. By this means little heat will be lost. The plan shews that the bottom of the apparatus is hinged, to admit of the ash being easily taken out. In this arrangement the air is forced in by steam jet, the bottom jets being used first; and as they get closed with ash, the upper range of jets is applied. Fig. 7 shows the boiler producer resting on four pillars of brick, air being forced in by a steam jet. When dirty waters are used, the boiler is continued round the bottom, as shewn on Fig. 8.

In many works it is desired to continue the making of gas without stopping for cleaning. In such cases a brick building is put below the boiler, using a blower, and fluxing the ash with lime, &c., and running it out at the bottom as slag. (See Fig. 9.) In this case steam is added above the tuyeres. The object of adding the steam is to secure more ammonia. The point at which the steam should be introduced will be regulated by the speed at which the producer is driven.

The tars, or oils, and ammonia got in this upward system of distillation are very much the same as those got from blast furnaces, so far as the writer's tests have gone; and, indeed, they should be the same, as the circumstances under which they are produced are very much alike.

Many coals gender and coke in gas producers, and so cause the producer to work irregularly; besides, the coke so made is close, and the air does not get through it with sufficient rapidity. In order to put both these points right, mechanical stirrers are introduced into the top portion of the producer, and steam or water is passed through them to keep them cool.

DISCUSSION.

The CHAIRMAN said they had had a good deal of light thrown on this subject by Mr Beilby and Mr Rowan; and, with the knowledge they had, he thought they might open the discussion to a certain extent that night.

Mr JOHNSTONE said that he had for long been impressed with the great waste they had in the combustion of ordinary coal, espe-

TO ILLUSTRATE Mr HENRY AITKEN'S PAPER.

FIG. 1.

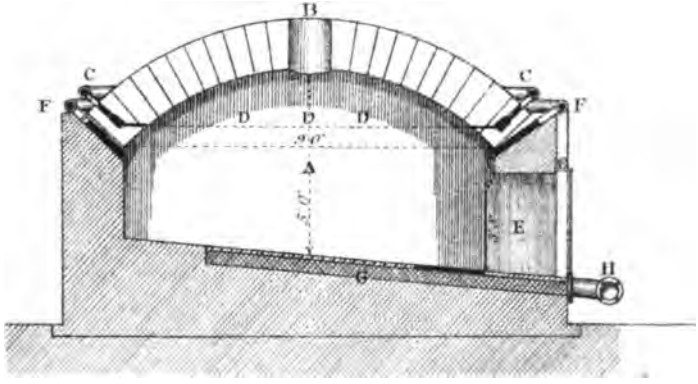


FIG. 2.

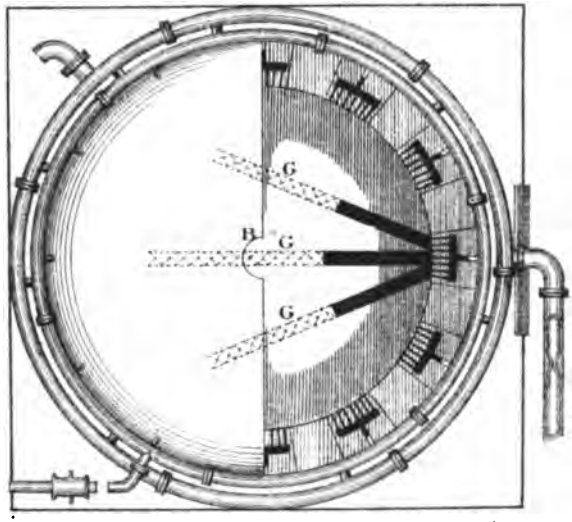


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FIG. 3.

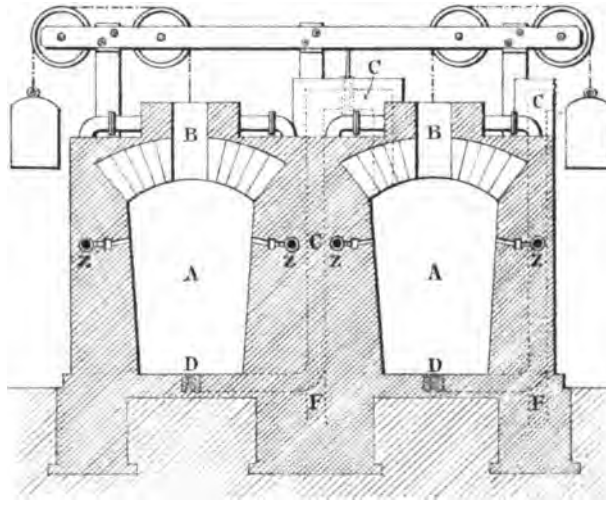

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FIG. 4.

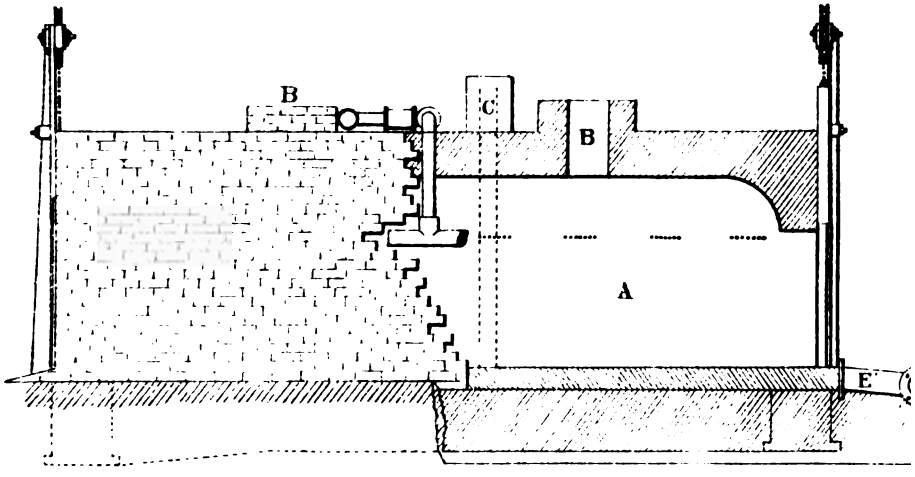

FIG. 5.

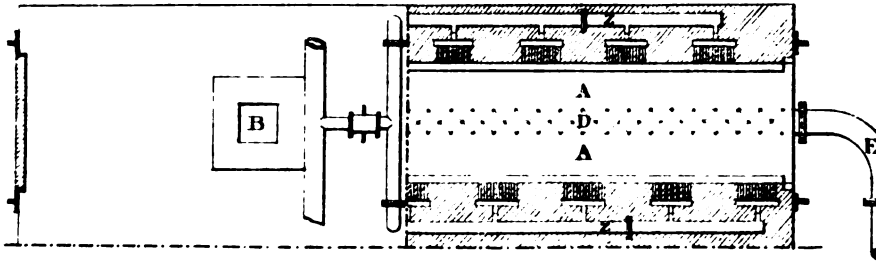

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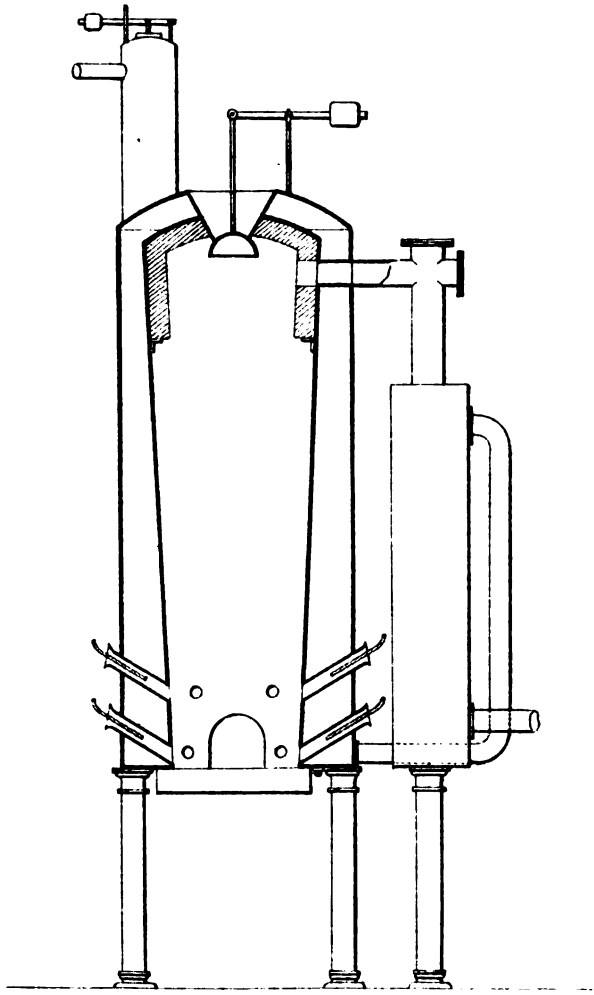
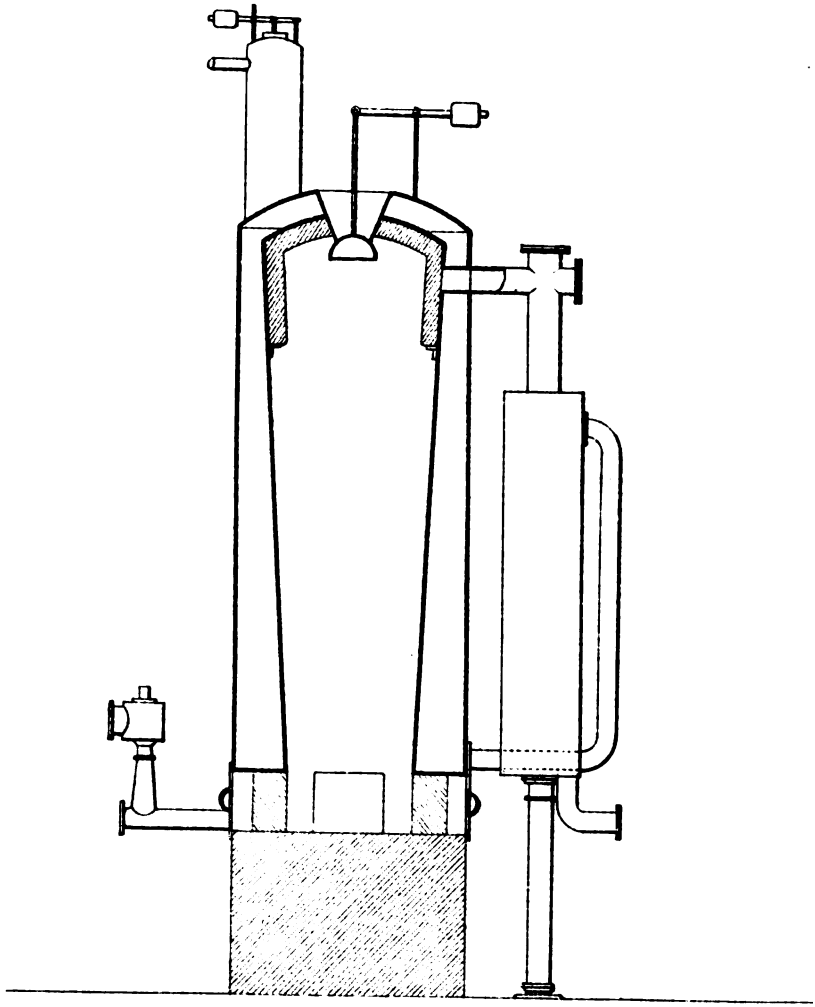
FIG. 6.



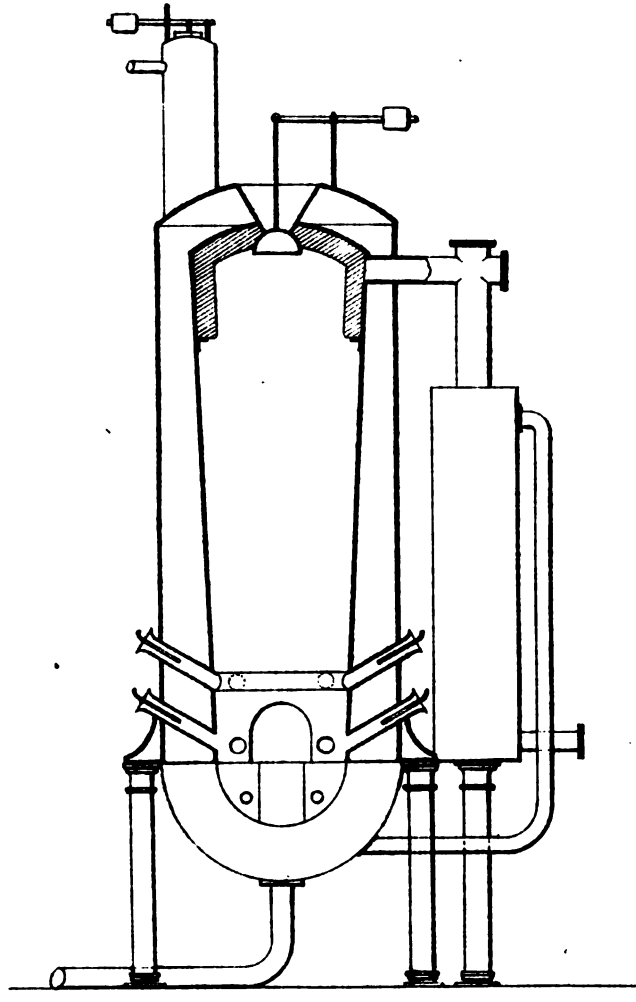
TO ILLUSTRATE MR HENRY AITKEN'S PAPER.

FIG. 7.



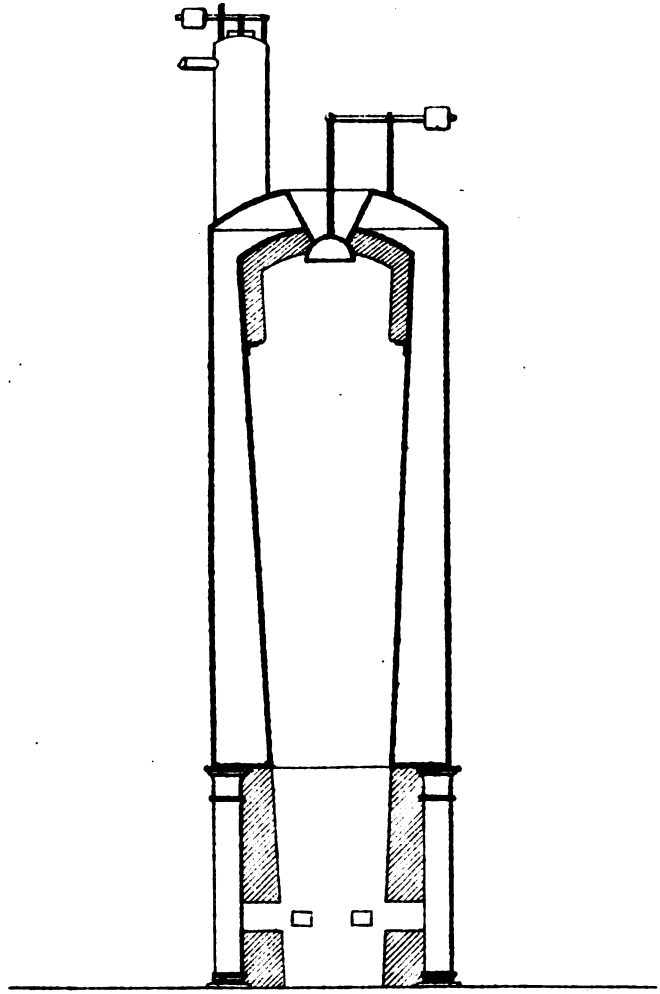
TO ILLUSTRATE MR HENRY AITKEN'S PAPER.

FIG. 8.



TO ILLUSTRATE MR HENRY AITKEN'S PAPER.

FIG. 9.



cially in the furnaces of their steam engines; and he emphasized the loss of fuel in the present mode of firing boilers, and also in the production of illuminating gas.

Mr RALPH MOORE said that in Scotland twenty million tons of coal were raised yearly; and he was within bounds in saying that 60 per cent. was sold at 5s per ton on the hill, and 40 per cent. at 1s per ton. If the gentlemen who had spoken on the subject were correct, they ought to be getting as much for the one sold at 1s as for that for which they were receiving 5s. He should like very much, as they had two or three gentlemen well able to enlighten them on the subject, to hear Mr Beilby or Mr Rowan on Mr Aitken's paper.

Mr DRINNAN said some of the gentlemen who had been spoken of as likely to throw some light on the subject introduced by Mr Aitken might wish a little more time to consider what they were about to say; and though he (Mr Drinnan) knew it savoured somewhat of presumption for him to rise up and say something on a subject of this kind, still he felt inclined to call attention to one or two things which he noticed while Mr Aitken was reading his paper. It certainly appeared to him a very interesting paper so far as he could follow Mr Aitken; but still he must confess he was somewhat disappointed with it. With regard to his first plan, he thought Mr Aitken assumed that one oven was able to do the work of two; but, so far as he understood the paper, this had yet to be proved. Mr Aitken stated also that in some imperfect experiments he had got 5½ pounds of sulphate, and went on to estimate that with more perfect experiments he would approach 12 to 12½. Again, in the second method, it was stated an experiment had been carried out somewhat imperfectly; and, with regard to the gas got, that it had not been actually measured but a certain quantity was calculated to have been got. He (Mr Drinnan) said it would have been well for Mr Aitken to have submitted the results of the actual experiments, because it might be found that such a great quantity of gas would not be got. He thought it would be well if Mr Aitken were prepared before another meeting with such results.

Mr ROWAN said anything he could say at this stage would be necessarily fragmentary; and he would prefer to have Mr

Aitken's paper in full before him, before criticising his plans to any great extent. He must say he found a difficulty in taking the subject up, because he shared the feeling of disappointment Mr Drinnan had expressed. He had expected, judging from the title of Mr Aitken's paper, nothing less than that they were to be put upon a new track altogether. But the coke oven which had been described they were familiar with, as it had been before those who were interested in those matters for some considerable time. At the same time, he must say he believed a good deal of the credit which was now given to Mr Jameson belonged to Mr Aitken for introducing, at an earlier date than Mr Jameson proposed it, this system of taking off the products of distillation. The other parts of Mr Aitken's plans, he would only remark upon generally to this extent, that the system of burning in these producers—burning downwards—would lead very shortly to the chambers being filled up with ash; and, therefore, he was not at all astonished to hear him advocating the adding of lime to the coal, and fluxing the ash into a slag to tap it out. That, however, was a plan tried for the first time at least fifty years ago, and was tried a second time in France, he thought, in the year 1871, or thereabout, and abandoned. The application of the water jacket, or boiler, to the gas producer, in order to take up the heat given out in the primary combustion of the coal, he believed was first suggested by M. Beaufumé, a Frenchman, and was described by the late Professor Rankine at the first meeting of the Institution of Engineers and Shipbuilders of Glasgow in 1857. There is a good illustration of the plan in the first volume of the Transactions of that Institute, but that plan has been since tried by several others—amongst others, Mr Wilson, who had a circular producer for marine work, designed in that way to avoid the necessity of having brick-work on board ship, and in order to make a producer generate its own steam. But it was not liked, because this water jacket lowered the temperature of the producer to a great extent, so that they did not get such an economical production of gas as from a brick-lined chamber. A certain temperature was necessary, as carbonic acid was first formed; and this was afterwards decomposed into carbonic oxide gas by the reduction of that carbonic acid passing through and

in contact with glowing carbon. This reaction, he should think, must go on also in the coke oven of Mr Aitken's even although he introduced carbonic oxide gas from the spare gas, and burned that on the top of the charge. The carbonic acid which was thus formed, as both air and gas were introduced, would be decomposed at the expense of the carbon of the coke to a small extent. It might not be an appreciable loss, but certainly that action must take place, and a certain portion of the charge be taken up in this way. The loss would not be so great as if nothing but air were introduced into the top of the chamber. When they studied the plans in detail, with Mr Aitken's remarks, it might be possible to say something more about them.

The CHAIRMAN said he was not prepared to say how much Mr Aitken's remarks were experimental, and how much were based on facts, but there was one thing that should be stated, viz., Mr Aitken was requested to read this paper, and certainly they must all listen with deference to one who had paid so much attention to this subject for many years. (Cheers.)

Mr AITKEN said with regard to Mr Drinnan's remark that he had not given results on a practical scale, he would simply observe that the results he gave of the work of the coke oven were those of actual working when imperfectly constructed, and he gave them as far as he had figures to justify his statement. These figures were absolutely correct, and he gave the results he had got by the more perfect manner of working, and as being what he believed to be the truth; because, although certain, he had no documentary evidence and therefore did not think it proper to give them as absolute facts what he could not produce documentary evidence to sustain. As regards the results got from the other arrangements, these no doubt were to a very large extent experimental, and he hesitated to give them; but they were all he had to give, and he had no opportunity of having anything soon owing to their works being shut up. Though these results might not have the same weight as if they had been conducted on a large scale, still they were quite sufficient to point the way as to how such work should be accomplished. As regards the gas not being measured, that was a thing it was not very easy to accomplish, and so had not been done. As regards

what Mr Rowan said about the gases being cooled in the boiler producer, that was quite true, but they must cool them to get out the oil and ammonia. So that was only hastening on the process. As to the making of carbonic acid in the boiler producer, he was not in a position to speak, but, looking to the fact that the gas had to ascend through a great body of hot coke, such, he thought, would not be the case. As regards his statement that in the beehive oven, the burning of the gases would absorb the carbon of the coke, he would say that was not done, because they knew the quantity of coal they put into the oven, and they knew the quantity of coke it would produce; and as they got within 1 to 3 per cent. of what the same coal gave in a close retort, it was clear no such action as Mr Rowan pointed at took place.

Mr ROWAN—Do you estimate the carbonic gas given off from the oven?

Mr AITKEN – No.

Mr RALPH MOORE said if he understood the papers aright, the coal treated was all of the coking kind. Would the results—*minus* the coke—of the two gentlemen who had addressed them be equally got from any coal?

The CHAIRMAN—I understand Mr Beilby's paper refers to non-coking coal entirely.

Mr BEILBY—The dross I have given the results of is a mixture of Main coal and Splint; a dross used in large quantities at Oakbank Works.

Mr AITKEN—Many different kinds of coal from Stirlingshire and Lanarkshire were used in the beehive oven; but only Slamannan and Hamilton Ell Coals were used in the other arrangements.

The discussion was adjourned, and the meeting separated.

NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES.

HOW TO SURVEY A BORE-HOLE.

In a paper read before the Victorian Institute of Surveyors last September by Mr E. F. Macgeorge, there is an account of a system, devised by the author, for surveying and mapping the true direction of bore-holes.

Serious deviations from the vertical, of bore-holes made by rock drills, have often caused much protracted and expensive search for mineral deposits proved by them, and have led to many suggestions for the discovery of such "lost bore-holes;" but to Mr Macgeorge is due the credit of making this possible, by a simple, and what seems an efficient method.

The surveying instrument, or "clinostat," is a cylinder of glass, six inches long, fitting into a brass jacket within a guiding tube or geoscope. The lower end of the cylinder terminates in a short neck and glass bulb about one inch diameter, within which is a magnetic needle, semi-floated under a buoy, so as to stand upright upon its pivot. This bulb is filled with a hot solution of gelatine which sets and holds the needle at its bearing.

Passing through an air tight stopping at the other end of the glass cylinder is a small glass tube, terminating in another bulb above, and containing a glass plummet with float, which, like the magnetic needle, is immersed in the gelatine solidifying fluid.

"The fluid then contains within itself an automatic registration of the inclination and "azimuth at which its containing vessel cooled, while, let us say, 500 feet deep in the "bore-hole to be tested; and it is easy therefore after its withdrawal, to tilt it to the "same angle and to the same quarter of the compass as before, by simply bringing the "embedded plummet and needle to the vertical and the northerly directions respec-"tively."

The clinostats in the guide rod are six in number; and, as tests are taken at several points in the bore-hole, great accuracy can be obtained.

Each clinostat, with its congealed contents, is now placed in succession in a recording instrument or clinometer, where, by means of two cross visioned telescopes kept truly in the same plane at every angle of inclination by a parallel motion, the clinostat is brought to the same angle of inclination at which it set; and by a circular mirror below the needle bulb, and into which is reflected the image of the needle, there is the means of plotting the angle of direction.

It is a well-known fact that bores frequently deviate from the plumb, and considerable error, even amounting to as much as 40 feet in a bore of 60 fathoms deep, has been observed. Mr Macgeorge's ingenious device for surveying bores, which he states has in many instances saved large sums in hap-hazard mine driving through the hard rocks of the auriferous reef district of the Antipodes, might frequently be of value in our own mining operations.

THE MARSAUT SAFETY LAMP.—In Part XI., Vol. XVII., of the Transactions of the MANCHESTER GEOLOGICAL SOCIETY, there is an interesting Paper on this new lamp by Mr Joseph Dickinson, H. M. Chief Inspector of Mines, in which the general features of the lamp are fully explained.

This lamp, which has obtained the commendation of the French Fire-damp Commission of 1882, may be thus described:—It stands 9½ inches high, and unscrews in two places, dividing it into three parts. The bottom part has the oil reservoir; and the middle part is the cage, into which are fitted the glass and gauzes. On the upper rim of the middle part are 18 vertical air-holes connecting with 6 horizontal inlets for air. The gauzes are double, and are telescoped the one inside the other, the inside gauze cylinder being a little shorter than the other, each being also capped with gauze. The Marsaut gauze has a mesh of 150 more holes per square inch than that of the common Davy. A cylinder of sheet-iron, with 9 outlets at top, and surmounted with a sheet-iron cap, forms the top part of the lamp, and, at the same time, a shield for the gauze. Among the advantages claimed for this lamp is this outside sheet-iron casing, which is said to protect the gauze from injury and clogging; to assist in extinguishing the light, by retarding the escape of gases should the lamp explode inside; and to readily admit of the lamp being put out by merely covering the outlet holes. Many severe trials of this lamp have been made at the Bessèges Collieries, France, along with other well-known lamps, with a result, on the whole, favourable to the Marsaut; and in connection with these tests Mr Dickinson points out the advisability of having the internal volume of all lamps reduced to a minimum, and the height of the glass as short as possible, to prevent gunning the flame of the explosion through the gauze. M. Marsaut, the inventor, also, in urging that lamps ought to be of as small a diameter as possible, states that it is safer to ascertain the presence of fire-damp by measuring the elongation of the lamp's full flame, than by reducing the flame so as to test by the "blue cap." This, as the writer truly remarks, is a surprise to many, but is borne out by the reasoning of small diameter lamps carrying the largest possible flame without becoming too hot, and with proper precautions against undue access of gas. A series of farther tests have also been made by Mr J. T. Green, of the Celynen Colliery, Monmouthshire, with the results that on exposure to quick varying currents of an explosive mixture, though the Marsaut lamp went out, yet in most cases gas continued to burn underneath the gauze, and which, Mr Dickinson says, would probably have fired through on a continuation of the test. This fact proved beyond doubt that some alteration would be required in the construction to make the lamp a serviceable one, and led Mr Teale to reduce the inlet and outlet apertures, and also to fix the casing to the cage, after which the lamp acted in a more satisfactory manner. It may be mentioned, that, as there is only the *glass* to protect the flame, with no horizontal gauze intervening, as in the Mueseler, this is a weak point in the lamp, and always an element of danger. That a mining safety lamp, in every sense of the word, is still needed, few will deny; and we look with interest to the completion of the experiments of the members of the Royal Commission on accidents in mines, as also to Mr Ellis Lever's safety lamp competition. J. HR.

The INSTITUTION of ENGINEERS and SHIPBUILDERS in Scotland.—The October number of the Transactions opens with the President's (Mr James Reid's) address. After giving a resumé of the papers that had been read during the previous session, he gives a very descriptive account of the progress of Mechanical Science. On railways he describes their useful and beneficial work; their extension, with a description of the City District Railway in course of construction through Glasgow; also, noting the results of the past year, with lower fares and increased facilities to third class passengers, which have not only benefitted them, but have considerably increased the receipts to the railway companies. There are now about 1000 miles of tramways in the United Kingdom. Their utility in cities is yearly becoming more apparent. Their construction costs about one half that

of railways; while their average earnings per mile are about the same. The cost of haulage by horse-power being very great, the companies look for some cheaper motor. The danger of steam in crowded streets has been against its adoption. The most feasible of the other methods which have been tried may be rope haulage with stationary engines. He also takes notice of the steady increase in the size of ships; the construction of works, such as canals, docks, the Channel Tunnel and the Forth Bridge; the employment of hydraulic power; the using of electricity as a motive and lighting power; and the employment of gas for heating and cooking purposes.

This number also contains a paper by Mr J. H. Biles, and discussion, on "THE STABILITY OF SHIPS," a subject which has engrossed the attention of the public since the catastrophe at the launching of the "Daphne."

In the December number there is a description with drawing, by Mr Laurence Hill, of Whiteford's DOUBLE LOCK RAILWAY CHAIR KEY and FISH JOINT, which consists in substituting an iron combination key for the wooden keys at present in use. It is said to have stood the test of practice satisfactorily for more than a year. Its first cost is from 4 to 6 times that of the common wooden key, but it is estimated that over a period of years it would be the cheaper of the two, and would require much less supervision.

The same number contains a paper, illustrated by diagrams, on THE COMPOUND ENGINE VIEWED IN ITS ECONOMICAL ASPECT, by Mr R. L. Weighton.

J. S.

The PROCEEDINGS of the INSTITUTION of MECHANICAL ENGINEERS for November, 1883, contain a paper on THE INVENTIONS of JAMES WATT; a Report on FRICTION EXPERIMENTS; and the first Report of the Committee on FRICTION at HIGH VELOCITIES. There is also in this number an Index for the whole of the Proceedings for 1883, and a list of the members, associates, and graduates of the Institution.

The paper on the INVENTIONS of JAMES WATT and his MODELS preserved at Handsworth and South Kensington, is by Mr Edward A. Cowper, and gives in a most interesting manner the history of the inventions of Watt. The author assumes the dates of Watt's patents—as being the most reliable—to be the dates of the inventions they represent. This places the invention of the separate condenser in the year 1769. Although this patent has no drawings attached to it, Watt's claims are very clearly stated in it. Drawings of a model supposed to have been made about this time, show the condensation of steam in a surface condenser, with air pump, &c., complete. This is noted as a remarkable instance of an inventor making an apparatus almost perfect at first. A plate is given, shewing one of Watt's earliest pumping engines, which is single acting, without rotary motion; with steam jacketed cylinder, separate condenser, injection pipe, and air pump; but without parallel motion. In the 1769 patent are clauses for a high pressure engine to work without a vacuum when water is scarce, the steam being discharged into the open air after it has done "its office." Watt, however, never followed up the use of high pressure steam. In his 1781 patent there are a number of ingenious contrivances for converting reciprocating into rotary motion; such as the "Sun and Planet" motion: the "Crown Cam" motion, and the "Ladder" motion. None of these, however, is as good as the crank motion, which is

supposed to have been stolen from Watt by one of his own workmen named Pickard, and patented by him. In the patent of 1782 we have the crowning invention of Watt's life: the engine has been made double acting; cylinder cover and stuffing box has been added; parallel motion has been invented and applied; and the engine perfected, so as to become the one great motive power for driving cotton mills, flour mills, and all other machinery requiring regular rotative motion. Another grand invention in this 1782 patent is the use of steam expansively; and so thoroughly did Watt understand this action, that he has drawn a good indicator figure of what would take place in the cylinder of an engine, if the steam were cut off at one quarter of the stroke. The paper contains interesting notices of many of Watt's other inventions; and a minute description of the articles found in the "Watt Room" at Heathfield Hall. This room is kept in the exact state in which the great inventor left it; with his lathe and bench at the window, and his tools lying about; his centre punch tied with a piece of gut to his vice, and his old leather apron lying near. In illustration there are 44 plates, containing 58 figures. Taken altogether, the paper is unique in its nature; well worthy of the author who wrote it, and the Institution before which it was read; and it is a gracefully-paid tribute to the memory of the great engineer whose inventions it describes.

The REPORT on FRICTION EXPERIMENTS is by Mr Beauchamp Tower, of London; and has been adopted by the Committee on Friction and presented to the Council. It deals first with the difficulty of applying lubricants to bearings; and points out that all the common methods of lubricating are so irregular in their action, that the friction of a bearing often varies considerably. In conducting the experiments, the bearing was made to run in a bath of oil. It was found that the bath need not be full; the results obtained were found to be the same when it was so nearly empty that the bottom of the journal only just touched the oil. All the experiments showed that the friction varied considerably with the temperature; and consequently the bath was regulated to 90°. This was accomplished by gas jets beneath the bath. It has been generally supposed that the co-efficient of friction was constant; but the results of these experiments show it to vary nearly inversely as the load: and also to be much smaller in quantity than was expected. Two experiments were specially made for the purpose of ascertaining the greatest load that could be carried by rape oil and mineral oil in the oil bath; the greatest load carried with the rape oil was 5731lbs. per sq. in., and the greatest load carried by the mineral oil was 625lbs. per sq. in. The experiments on friction at different temperatures indicate a very great diminution in the friction as the temperature rises. Using lard oil with a speed of 450 revolutions per minute, the co-efficient of friction, at a temperature of 120°, is only one-third of what it is at 60°. A very interesting discovery was made when the oil bath experiments were nearly completed. The experiments being carried on at the time were on mineral oil. The bearing had seized with a pressure of 625lbs. per sq. in. The brass was taken out to be examined, and the opportunity was taken to drill a ¼in. hole for an ordinary lubricator through the cover and the brass. On starting the machine, the oil overflowed through the hole in the cover, and a wooden plug was inserted in the hole; but this was promptly shoved out by the oil in a way that showed it was acted on by considerable pressure. A pressure gauge was then screwed into the hole; and, on the machine being started, the pressure as indicated by the gauge gradually rose to above 200lbs. per sq. in. The gauge was only graduated up to 200lbs., and the pointer went beyond the highest graduation. The mean load on the journal at the time was only 100lbs. per sq. in. This experiment showed conclusively that the brass was actually floating on a film of oil, subject to a pressure due to the load; the pressure in the middle of the brass was thus more than double the mean pressure. No doubt, if there had been a number of pressure gauges connected to various parts of the brass, they would have shown the pressure to have been highest in the middle and diminishing to nothing towards the edges of the brass.

There are 11 tables given, showing the details of the experiments with different lubricants under the different conditions of speed, temperature, and load. An interesting discussion (which was adjourned) followed the reading of the paper.

The first REPORT of the COMMITTEE on FRICTION at HIGH VELOCITIES is by Professor A. B. W. Kennedy (reporter). The Professor remarks that, as the essential question involved in this is the influence of velocity upon frictional resistance, it is not advisable that he should give any account of what has been written on the subject of friction generally; but little work has been done in connection with this question, and most of it inapplicable to the ordinary work of the mechanical engineer. Professor Fleeming Jenkin has recently been making some experiments in connection with this matter; but, as these dealt principally with low velocities, they do not throw much additional light on the subject. Professor A. S. Kimball finds that the friction between pieces of pinewood decreases rapidly as the speed increases. Professor R. H. Thurston has come to the conclusion that with a cool and well lubricated bearing the co-efficient of friction increases with the velocity; and, approximately, as its fifth root at all speeds exceeding 100ft. per minute. This is directly antagonistic to the experiments of Poirée and Bochet, as well as those of Captain Galton and Mr Westinghouse, who all find a great diminution of the co-efficient of friction with increase of speed. It would appear from the contradictory nature of some of the experiments, that pressure plays an important part, as well as velocity; and that, in carrying out any experiments on this subject, it would not be advisable to dissociate the question of varying pressure from that of varying velocity. J. P.

CHESTERFIELD AND DERBYSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

On the application of FLEUSS' PATENT NOXIOUS GAS APPARATUS and FOSTER & FLEUSS' PATENT SAFETY MINING LAMP, at Seaham Colliery, by W. F. Howard. Vol. IX., p. 346.—It is almost out of date now to refer to the subject of the above paper; but it gives some interesting details of the training of men unfamiliar with its use in a special emergency, and the difficulties to be overcome in such a case. The experience of one actually engaged in exploration with the aid of this dress must be valuable at this stage of the invention's history; and with this, and a detailed description of the dress, illustrated by drawings, the paper is taken up.

On MINING COAL by COMPRESSED LIME, under Sebastian Smith and Moore's Patent, by Sebastian Smith. Vol. IX., p. 95.—The consideration of the above method of coal getting by a deputation of our Institute [see Vol. IV., p. 82] renders detailed notice of this paper unnecessary. The suggestion of a member of that deputation, that unslacked lime cartridges finding their way into the waste might lead to fires therein, caused that question to be submitted to Professor Abel, who, after experiment, expressed himself satisfied that this is impossible. It may safely be concluded that the process is exhibited under the most favourable light in the above paper; and what detailed experiments are given make it compare favourably with wedging as a means of getting coal. In an appendix is given a list of places where the process has been used, with the local circumstances and the results in general terms. In the discussion upon the paper, the general opinion was not favourable to Mr Smith's process. None of the critics could compare the results from the lime process with the results by wedging; but put it against gunpowder, with

which it would not bear comparison on the head of cost. It is but fair to say, however, that Mr Smith does not claim for the lime process more than that it is safer than gunpowder, and cheaper than wedging. Comparing the results obtained by the lime process at Shipley Collieries over a year's working with his former experience of wedging, Mr Smith shews an advantage of 17 per cent. of round coal in favour of the former. The discussion seemed to shew that the lime process of coal getting is very much affected by local influences: such as mode of working, nature of the roof, and of the coal itself.

On a SELF-ACTING ARRANGEMENT for UNLOADING and LOADING COLLIERY CAGES (Fisher's Patent), by T. G. Lees. Vol. XI., p. 209.—The method of manipulating the colliery trams at the pit bank, discribed in the above paper, has been worked for upwards of four years at Clifton Colliery, Nottingham. Underground, the trains stand on an inclined roadway and run on the cage by gravity, forcing the empty train off; the time occupied being 6 seconds. On the bank, working by manual labour, 10½ seconds were required to remove the full trams from, and put the empty trams upon, the cage. By the mechanical method described, this operation is effected in 6½ seconds; saving thus 4 seconds each journey. To describe such a contrivance by words without aid of diagrams is impossible; but, broadly stated, it consists of an arrangement of levers by which the weight of the cage and loaded trams, as the cage comes to rest upon the "shuts," elevates one end of the rails, which are mounted on trunnions on the cage, and depresses the other. Simultaneously, the rails upon which the empty trams stand on the scaffold are inclined by steam, or compressed air in a cylinder, raising the one end. The guard holding the full trams in position on the cage is removed by mechanical means; the loaded trams run off, and the empty ones on, the cage; the guard is re-inserted in time to stop the empty trams; and the whole mechanism is put into its original position by the removal of the cage from the shuts. The above is, of course, only applicable to single-decked cages, but its application by modified and extended arrangements to double-decked cages is described: the trams from the upper deck being lowered to and raised from the main scaffold level by self-acting balance cages.

The discussion on the paper was short but entirely favourable, and elicited from the inventor the information that at Clifton Colliery the arrangements had enabled them to increase the output seventy tons per day with three men less on the bank. The cost of the apparatus was about £70.

The KOEPE PATENT SYSTEM of WINDING at The Bestwood Collieries, by Robert Wilson. Vol. XI., p. 253.—The Koepe system of winding is the invention of a German colliery manager of that name. After a lengthened trial period, when it was used for winding coal only, the Government Inspectors made a searching examination of the system before reporting as to its efficiency; upon which report depended its adoption for raising and lowering workmen. The report set forth that the Koepe system is in every respect more economical than the ordinary method of winding, and has also elements of greater safety. A pulley, with a grooved band of hard wood encircling the rim, takes the place of the ordinary winding drum; and the friction of the wire rope on one half of the periphery of the pulley is found sufficient to raise the load when the ropes are balanced by the balance rope attached to the bottom of the cages. The single winding rope, therefore, is attached at one end to the ascending cage, passed round the winding pulley, and attached to the descending cage. The balance rope passes round a loaded movable pulley in the pit sump, and is attached to the bottom of the cage; or, in Mr Wilson's arrangement, to the winding rope. Part of the original invention was a safety arrangement consisting of two light ropes attached to the cages, and passing over pulleys on the pithead frame, supported on springs sufficiently strong to bear the weight of the ropes, and part of the load if desired. In case of the winding rope breaking, the whole weight of the load is thrown on these safety ropes, compressing the springs on which the

bearings rest, bringing the rims of these pulleys into contact with the wood, and causing friction sufficient to prevent the descent of the loaded cage. The advantages claimed by the inventor for the Koepe System are:—

"Balancing the winding ropes, thus reducing the size of the engines, the consumption of fuel, and the total cost of plant for any given load. The same size of engine will raise a given load at a given speed from any depth of shaft, avoiding the use and consequent cost of a heavy drum. One winding rope only necessary instead of two. Safety from overwinding. Less wear and tear upon plant."

Experiments by the patentee shewed a saving of 44·4 per cent. in fuel for the Koepe system compared with the parallel drum, while the saving of capital in fittings varies from 25 to 75 per cent. It is fair to say that this saving is questioned, and it certainly does seem very large when placed alongside the difference in the fittings. The arrangements adopted for engines, pulleys, and screens at Bestwood Collieries are described at length and illustrated by diagrams. The discussion of the paper turned principally upon matters of detail, and brought out some weak points of the system; particularly the difficulty encountered from the necessity of frequent capping of the rope, which, by the time the rope is worn out, introduces long lengths of chain at each end. The right of Mr Koepe to the credit of the invention was questioned, and one case of the use of a system of winding in South Wales closely resembling it, if not exactly the same in principle, was mentioned as existing forty years ago.

On the PRINCIPLES of ELECTRIC LIGHTING and TRANSMISSION of POWER by ELECTRICITY, by Sydney F. Walker. Vols. XI. and XII.—Under the four sections—(a) electric lamps, (b) dynamo electric machines, (c) electrical accumulators, (d) transmission of power by electricity—the author treats his subject at great length. Each of the sections is considered with special réference to the bearing of electrical science upon mining operations; and to those interested the paper is of much practical importance, giving as it does what has been ascertained as to the adaptability of electricity to various mechanical operations up to date. J. H.

"The HASWELL MECHANICAL COAL-GETTER; An invention for working Coal without the aid of Gunpowder or other explosives." By W. F. Hall. Trans. of NO. of ENGD. INST. of M. and M. ENGINEERS, Part II., Vol. XXXIII.

Gives a description of an invention which the author considers may to a great extent take the place of gunpowder in working. The machine, of which drawings are given, is a combination of the screw, lever, and wedge. The force is applied by a screw and levers, and the bursting action of the wedge is brought to bear on the back of the "jud," or portion of coal to be taken down. It consists of two blocks, expanded by a wedge at the end of a rod, which is thrust in by a crosshead, moved by four pairs of levers—two pairs fastened to the crosshead, and two pairs to the end of the machine; these levers being forced together by a screw, working through a nut at the points where the back and front pairs of levers are joined, and turned by a ratchet brace. It is neither a difficult nor complicated machine to work; nor does it require skilled labour to manage it. As the bursting strain is gradually applied, the coal is brought down in large, unshattered blocks. To quote the words of the writer:—"Not merely is there a less percentage of small; but the natural cohesion of the round is in no way destroyed; so that it does not fall to pieces in transit, as in the case of coal brought down by explosives." Detailed accounts are given of eighteen different experiments with this machine, work-

ing in the Low Main Seam, Haswell Colliery, a hards team coal 3 ft. 4 in. to 3 ft. 6 in. thick at a depth of 135 fathoms; and two experiments in stone work, as well as the following summary, are also given. H. R. M.

SUMMARY OF EXPERIMENTS, LOW MAIN SEAM, OCTOBER, 1863.

No. of Experiment.	Description of Place Worked.	Length of Face.	Holes 3½ in. Diameter. No.	Holes 3½ in. Diameter. Depth.	Depth of Kirving.	Coal brought down.	Time occupied in Wedging.	Remarks.
		Ft.		Ft. In.	Ft. In.	Tons.	Min.	
1	Long-wall jud, loose at one end	33	1	3 8	3 6	10½	21	.. ..
2	Do., do. ..	27½	1	3 8	3 6	8½	22	.. ..
3	Do., do. ..	20½	1	3 6	3 4	6½	6½	.. ..
4	Do., do. ..	21	1	3 8	3 6	6½	16½	.. ..
5	Do., do. ..	28½	2	3 8	3 6	9½	10	A hitch in this place, causing two holes to be made.
6	Do., do. ..	27	1	3 8	3 6	8½	17	.. ..
7	Do., do. ..	24	1	3 8	3 6	8½	44	The seam rises 1 in 24 from the hole preventing the coming down freely.
8	Board, fast at each side ..	16	2	3 8	3 6	5	27	.. ..
9	Long-wall jud, loose at one end	27	1	3 6	3 4	8	12	.. ..
10	Board, fast at both ends ..	18	2	3 8	3 4	5½	29	.. ..
11	Long-wall jud, loose at one end	21½	1	3 6	3 4	6½	15½	.. ..
12	Do., do. ..	24	1	3 6	3 4	7½	25	.. ..
13	Do., do. ..	24½	1	3 9	3 6	7½	11½	.. ..
14	Do., do. ..	27½	1	3 9	3 6	8½	21½	.. ..
15	Board, fast at each side ..	16½	2	3 9	3 6	5	46	.. ..
16	Headways way, or end on do.	18	3	3 9	3 6	6	27½	.. ..
17	Long-wall jud, loose at one end	18	1	3 3	3 6	..	..	Kirved in top of seam, hole in bottom. The whole of the coal was lifted to back of jud.
	In Main Coal—							
18	Long-wall jud, loose at one end	30	3	3 2	3 0	..	..	Kirved in 18 in. of ramble, above the seam. Three holes at bottom, lifting all the coal to back of jud.

[ADVERTISEMENT].

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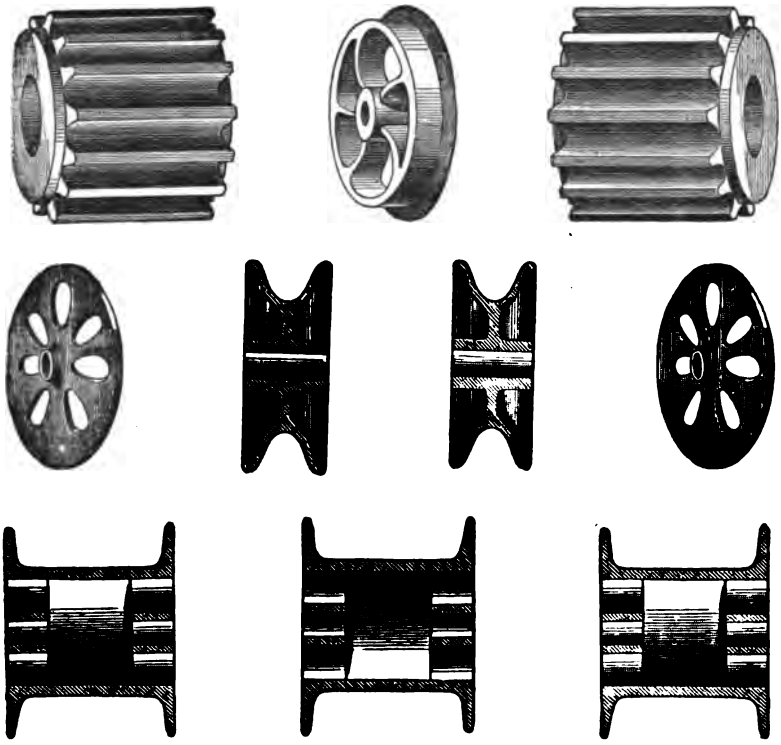

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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 13th MARCH, 1884,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,

JAMES M'CREATH, Esq., President, in the Chair.

Upwards of seventy members were present.

The minutes of the last General Meeting were read by the Secretary, and confirmed.

The following gentlemen were elected by ballot, and admitted as Ordinary Members :—

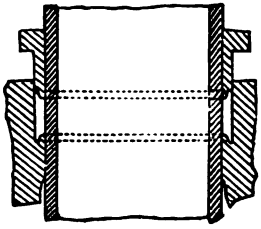
JOHN WILLIAMS, 16 Blanche Street, Dowlais, So. Wales.
NORMAN M. HENDERSON, Broxburn Oil Works, Broxburn.
ALEXANDER DICK, Denby Colliery, Derby.
ALEXANDER KIRKPATRICK, Allanshaw, Hamilton.

The Council submitted a list of their members who were not eligible for re-election for session 1884-85; and the nomination of office-bearers for election at the annual meeting was then made.

DISCUSSION OF MR ROBERT THOMAS MOORE'S PAPER ON AN IMPROVED ARRANGEMENT FOR WORKING UNDERGROUND PUMPS BY MEANS OF HYDRAULIC PRESSURE.

The PRESIDENT having announced the resumption of the discussion on this paper,

Mr R. T. MOORE called attention to the drawing on Plate XIV., figure 3, and said the stuffing box was wrongly shewn. The end of the stuffing box should be rounded, as shewn in wood-cut.



Mr LAURENCE HILL asked what friction there was in working by this system as compared with rods.

Mr MOORE said the question of friction appeared to be one of great importance. There had not yet been any experiments here to test the friction due to the pipes and pump. The only test was the case mentioned in his paper where a pump in California shewed an efficiency of 89 per cent. There had been various tables prepared, however, giving the result of experiments on the friction of water in flowing through pipes. Taking those given by Molesworth, the head of water necessary to overcome the friction due to driving water at a velocity of five feet per second through a pipe $2\frac{1}{2}$ inches diameter, was given at 4 per cent. of the length of the pipe. This, with a pipe 130 fathoms long, was a head of 5·2 fathoms, or taking the two pipes, 10·4 fathoms. That is to say, with a pump 130 fathoms away from the engine, a head of 10·4 fathoms, or a pressure of 27lbs. per square inch, would require to be added to the pressure on the power plungers in order to overcome the friction of the water in

the pipes; and, as the working pressure was 1000lbs. per square inch, this friction represented a loss of only 2·7 per cent. of the power. If the engine were twice this distance from the pumps, there would be twice this percentage of loss, the percentage of loss increasing as the distance between the engine and pumps was increased. This was, however, no great thing, as the loss for 500 fathoms was only 10 per cent., and would be less if a slower velocity were taken. These figures were verified by results got from siphons. He knew of a case where 100 gallons of water per minute ran through a siphon 4 inches diameter and 1500 feet long with a fall of 16 feet. The velocity was here 3 feet per second, and the loss of head due to friction could not be more than 16 feet or 1·07 per cent. of the length of the pipes, which agreed almost exactly with the results given in the tables. He had no doubt many of the members had siphons running at equally high velocities with an equally small amount of friction.

The PRESIDENT said he did not quite understand why Mr Moore should say at p. 297, that 5 per cent. of the head was lost in friction, because it was usually said the friction was independent of the pressure. In that case they could only have the same friction with a thousand pounds as with ten pounds pressure.

Mr MOORE quite agreed with the President that the friction of the water in the pipes was independent of the pressure to which it was subjected. When he said the head due to friction, he meant the head of water which represented the loss of pressure due to the friction in the pipes; and this, with a given velocity and diameter of pipe, was a certain percentage of the length.

Mr DRINNAN would be inclined to call in question the small amount of friction which Mr Moore said was caused by the motion of the water in the pipes. Certainly he was inclined to believe that water, at a pressure of a thousand pounds, would cause more friction than if it was merely a head of water; but he understood, from the remark the Chairman had let fall, that nothing was allowed for that. This was new to him, and that was one of the things he intended to call attention to. He also intended to refer to the number of stuffing boxes. Having had some little experience of the friction caused by stuffing boxes,

and keeping in view that they would require to be tightened up and to be kept tight, he would have expected a greater amount of friction than Mr Moore stated was really the case. As, however, it was said they really obtained in the pumps 89 per cent. of the amount of work in the engine, he did not feel at liberty to question the statement as he could not refute it. There was another thing that he thought ought to be taken into consideration, viz., the question of cost, and he thought Mr Moore would do them a great service if he were to give them some idea of the relative cost of the system which Mr Moore, of San Francisco, had worked and the ordinary system of pumping by means of pump rods. As to trouble, he thought those stuffing boxes in the one system would entail as much trouble as the pump rods in the other. A well fitted up system of rods lasted for a long time, in all likelihood as long as the colliery itself, and he did not think the amount of work expended would be more than would be expended in keeping tight the joints and all those stuffing boxes which would frequently require to be repacked. On that account, he thought the cost of maintaining them would be as great as that of maintaining their pump rods,—that was, where they had a set fitted up fully equal to the work they had to do. For moderate depths, he would be inclined to question the advantage until he had submitted to him the relative cost of the two systems.

Mr DAVID JOHNSTONE said he had offered to fit up at several collieries more than two years ago the same system; but was met with the objection that, as the owners had not seen it working they would not take the risk of having it fitted up. His own opinion, from what he had seen of it, was that it was a much better system than pumping with rods. As to the question of friction, he gave tables in his last paper [vol. iii. p. 159] that any of the members might refer to. The percentage of work in the pump appeared to him exceptionally high, and he really did not think it could be got with any length of pipes, because they knew that every yard of pipe gave a certain amount of friction. The percentage given might be the percentage after allowing for friction in the pipe. A pipe might be lengthened until the water would scarcely run through it, and the amount of work

they got out of any hydraulic machinery was to a very great extent dependent on the size and diameter of the pipe. The stuffing boxes he could not make out from the small drawings. Plunger stuffing boxes were things he was altogether against where they could be avoided; because they had a large area of stuffing box, and to keep them tight entailed a great amount of friction. Hydraulic power was coming very much to the front, and although it might be a little costly at first, he had no doubt that if properly employed, it would give satisfaction. It would be costly, especially if they had to use gun metal, but they had now got a new metal,—aluminium bronze,—which could be made of the strength of steel, and was not corroded by water. Had he known of it when he made his engine he would have adopted it. In getting a piece of gun metal from the brass foundry, it was not known how it would turn out; some of it would not give the strength of a clay pipe, but with such a metal as he had referred to, where they could have a strength of something like 20 or 25 tons tensile strength on the square inch, and which was non-corrosive, it would greatly facilitate the use of hydraulic power for pumping and mining purposes.

Mr J. M. RONALDSON said many of them would remember that at their summer meeting in Edinburgh in July, 1880, Mr William Barclay of San Francisco brought before them a system of hydraulic pumping in which a steam engine on the surface transmitted power through a column of small water pipes to a power plunger which forced down the pump plunger; this plunger being again raised to the top of the stroke by means of two wire ropes connected to the steam engine. At the discussion upon the paper on 9th September, objection was taken to these wire ropes, and it was suggested to dispense with them by raising the pump plunger by means of another power plunger driven by the steam engine through a second column of small pipes. These taken together give the identical system brought forward by Mr Moore. Of course, Mr Barclay's was only single acting; Mr Moore's was double acting, and Mr Moore had introduced a relief valve between the two pipes and various other improvements. But so far as the principle went, that had already been before the Mining Institute. He would like to ask

if Mr Moore could give the details of how the 11 per cent. of loss between the power given out by the steam engine and the water forced up the pit was arrived at. Was the horse-power of the engine indicated, and was the quantity of water raised to the surface from a given depth measured, so that the exact relation between the two could be ascertained?

The PRESIDENT asked if Mr Moore had looked into the matter of what percentage of the loss of stroke would arise from the compression of the water.

Mr JOHNSTONE said more than the 11 per cent. of friction would be required to drive the engine. It could not be ascertained unless they were driving it first empty at the same velocity and driving it at its work, and taking the difference.

Mr ROBSON thought it was quite possible for a pump to give out 89 per cent. of the power put into the steam engine.

The PRESIDENT asked if Mr Robson had ascertained that.

Mr ROBSON said he could not then mention the particular case, but he had seen it.*

Mr JOHNSTONE asked how they arrived at it.

Mr ROBSON—Precisely in the same way as Mr Moore explained. He did not know if, in the case referred to in the paper, the engine was indicated; he rather thought not. He thought the 11 per cent. had been got at from another hydraulic arrangement.

Mr MOORE said the 11 per cent. was got in this way: There was a hydraulic engine at the bottom of the pit, driven by a head of water, and lifting a certain quantity from the bottom to an intermediate level. The quantity of water raised by the engine, multiplied by the height to which it was raised, was 89 per cent. of the quantity of water coming down the driving column multiplied by the head; giving thus 11 per cent. as

* Mr Robson afterwards sent the following note:—In a paper read before the North of England Institute in 1870 (Vol. 19, page 218), particulars are given of a horizontal non-condensing pumping engine working two lifting sets, each 50 fathoms in depth, where the percentage of useful effect was 89·22. Another engine (Boulton & Watt) working four lifting sets, gave 93 per cent. In this example, however, there was a great amount of leakage at split pumps and bad joints, so that the calculated efficiency was in excess of the actual work done. A compound rotative beam engine at the Surbiton Station, Lambeth Water Works, working two double-acting four-valve pumps, gave 86·5 per cent. useful effect. If the loss of power by working the air pump be estimated at 4·5 per cent. this would give 91 per cent. useful effect for a non-condensing engine.

the total loss. With regard to the President's remarks as to the compressibility of water, he had studied that question, and he found that it did not affect the utility of the arrangement. Water compressed $\frac{1}{23000}$ of its bulk per atmosphere of pressure, and, with a pressure of 1000 lbs. per square inch or 68 atmospheres, the compression would be nearly 0·3 per cent. The diminution in the length of each stroke in the pipes would thus be 0·3 per cent. of the length, but as the speed of the plunger was only one-third of that of the water in the pipes, the contraction of stroke due to the compression of the water was 0·1 per cent. of the length of the pipes. Thus, in a length of 100 fathoms, a 4-feet stroke in the engine on the surface would only be 3 feet 5 inches in the pumps underground. There was no loss of power in this, as the power given out by the one column expanding was the same as that absorbed in compressing the other. The action was precisely the same as that which would be produced by putting a spring between the piston rod and the plunger. Power would be absorbed while the spring was being compressed, but it would be given out again while it was expanding. The diminution in the length of the stroke could easily be prevented by making the area of the power plungers on the surface proportionately greater than that of the plungers underground.

The PRESIDENT remarked that the contraction would be reduced a half by opening the valve between the two power pipes at the end of the stroke. This would make the pressure in each power pipe 500 lbs. per square inch at the beginning of a stroke.

Mr MOORE said, with regard to Mr Drinnan's remarks about the friction of the stuffing boxes, that when they were rounded, as shewn in the woodcut (page 320), there was not nearly as much pressure on the plunger, and the packing was found to last much longer. There was no difficulty in keeping stuffing boxes of this form tight under these high pressures. Indeed it was found that it was easier to keep the packing tight under 1000 lbs. pressure than under 40. With regard to the cost of upkeep he was scarcely in a position to speak. He had gone into some figures as to the first cost and found that for shallow lifts this arrangement compared favourably with pump rod engines. With deep lifts, there was no doubt they would be more economical, and in

dook pumps much more economical. As regards the keeping of the joints tight, there could be no great difficulty in that. The 11 per cent. was calculated (he spoke from memory) on over 2000 ft. of pipes. Of course, as they got longer, the percentage of loss due to friction would be greater, but as he said before the amount of friction was a very small proportion of the working pressure. It was not as if a proportion of the actual quantity of water pumped was taken. There was but a small quantity of water in the power pipes, and on that account the friction was very much less. With regard to dirty water, the water in the power pipes was never changed, so that there could be no difficulty in filtering enough water to fill them. No doubt, gun metal plungers would be an advantage as they would cause less friction; but they were not required on account of the quality of the water, any more than they would be with any other class of pump. With regard to Mr Ronaldson's remarks as to Mr Barclay's paper, he had not seen it since it was read, but if he remembered aright he proposed to modify the grasshopper beam engine by fixing a plunger to the beam and forcing down the plunger underground through a single column of water; this column of water and the plungers being lifted by wire ropes fastened to the beam of the engine. The pumps were to be put in the shaft in lifts after the usual Cornish fashion. It was a very crude scheme altogether, and very different from the system described in his paper. Even with the suggestion of another set of pipes, it would still have been a very imperfect machine, if it would have worked at all. The relief valve was the great feature of the invention; without it, it would not work satisfactorily. Mr Johnstone's plans had never been before them, and he could not say in what they differed from the system patented by Mr Joseph Moore.

The PRESIDENT brought the discussion to a close by proposing a vote of thanks to Mr Moore for his very valuable paper, which was heartily accorded.

DISCUSSION OF MR HENRY AITKEN'S PAPER ON "HOW TO MAKE THE MOST OF OUR COAL IN COKING IT, &c."

The PRESIDENT, in introducing the discussion of this paper, read a letter from Mr Aitken intimating that he could not come as his brother had fallen in Egypt. They must all regret the cause of his absence, but in order to get the discussion finished with this year's transactions, any gentleman who wished to make remarks would perhaps do so, and Mr Aitken would have an opportunity of replying in writing.

Mr ROWAN said he noticed that Mr Aitken made an estimate, on p. 300, as to the heating value of the oils obtained from coke ovens and producers which was, he thought, over the mark. They would notice that he said the heating value of the oil was about 28,000 heat units as compared with 14,000 units for coal. That was to say that the oil is double the value of the same weight of coal. A few years ago, some very careful investigations as to the value of liquid fuel were made both by Professor Rankine and Dr. Benj. H. Paul. Professor Rankine published some papers on the subject, one of which was read before the Royal United Service Institution, London, and Dr Paul had also published a careful examination of the subject. Dr. Rankine's estimate of the heating value of liquid hydro-carbons such as "dead oil" was 19 lbs. of water evaporated from 62° Fah. to 212° Fah., while Dr Paul's estimate was only from 16 to 18 lbs. It was not an uncommon thing now for 11 or 12 lbs. of water to be evaporated per pound of coal used, so that the heating value of these oils as compared with coal could not be accurately taken as double. That, of course, affected the value of those oils as fuel very much; and taking a ton of coal at nine shillings, which probably was over the mark, a ton of oil contained 213 gallons, and if they took that at 1d a gallon that meant 17s 9d per ton; so that a price very much less than 1d a gallon must be the ruling price before these oils could be introduced as fuel in competition with coal. This was a very important question, as the quantity of tar and oils that was likely to be produced in the future from blast furnaces, coke ovens, and gas producers was likely to be

very large, and it was of great importance that an outlet should be found for such products in that direction. But there was no use running away with the idea that a large price could be got for them. That was the result as regarded their practical value at present for steam raising.

At the end of the first paragraph, at page 304, and again in the first four lines of page 305, Mr Aitken talked of taking the products of one producer through a second, passing the gas from one producer through the material in the second. He hoped to show later in the evening a plan invented by Mr Sutherland, formerly of Liverpool, now of Birmingham, who had patented the same idea. He did not know what the value of it was likely to be, but it had already been patented.

In the third head of his paper, further down p. 304, Mr Aitken spoke of working one form of apparatus, which was also proposed for a coke oven, as a gas producer, and so soon as the coke was all consumed in making gas and the apparatus was filled with ash the air was shut off and the chamber emptied of ash. It must be evident, he thought, that to empty entirely a chamber of that sort would involve a considerable loss, because the chamber during that operation, which must take a considerable time if it was of appreciable size, must be largely cooled down, and in these days, when every effort was made to economise heat in such operations, he was afraid that system would not be likely to give the best results. He had no more to say about the water jacket producer than he had said at last meeting, except that he noticed in the plans that the air and steam jets are introduced entirely at the sides. Now, it had been found by long experience with gas producers that when the air was admitted at the sides there was a loss occasioned by the air creeping up the sides of the chamber and not combining with the carbon of the fuel, and that was why efforts had been made to introduce the currents of air and steam as far as possible towards the centre of the fuel. The presence of steam in those jets also, of course, altered to some extent the character of the gases and of the oils coming off. He saw that Mr Aitken compared the quality of those gases, oils, and tars, with those given off from blast furnaces. It was impossible to introduce steam into a blast furnace, because of the cooling effect

which that would have upon the burden, and it would be detrimental to the production of iron. In gas producers it was different, and the presence of steam was likely to alter to some extent both the gas and the liquid products as compared with what was obtained from blast furnaces.

Mr BEILBY said Mr Rowan's remarks as to the value of oil fuel were very interesting. With the extraction of the products of coke ovens and blast furnaces on such an extensive scale, one naturally looked to what the outlets of these were to be. A good deal of discussion had taken place in the north of England in regard to those oils, which had been recently carefully analysed, and their constitution was now much more thoroughly understood. They were told that a large quantity of paraffine had been obtained, but he thought this had been proved to be incorrect, and no Scotch oil refiner would attempt to refine it. Recently, Mr Isaac Lothian Bell, sent him a sample, and he examined it for paraffine and found that instead of 20 to 25 per cent. it contained probably not half a per cent. Of course, they as refiners would never, so long as they got Scotch oils at 2½d containing 10 per cent. of paraffine, think of buying this at 3d per gallon containing a half per cent. of paraffine. All this showed that the manufacture of large quantities of this kind demanded an outlet to be found for them. This outlet must also necessarily be in the direction of fuel, and it remained to be seen whether a sufficient stimulus will be given to invention in connection with its use, and sufficient inducement to justify coke producers in separating the products. When the price fell to ½d a gallon, it became questionable as to their recovery being worth while. The only oil gas used was that used by the Railway Companies in lighting their carriages. This had been done in England, and it formed an outlet for a moderate amount of gas oils. In Belgium and certain German towns, quantities were used; but he thought they would hesitate to give up coal for gas-making purposes in favour of oil products.

Mr RALPH MOORE said he was struck with the remarks of Mr Beilby as to the use of those oils as fuels, but, he apprehended, until further experiments were made to test their value, they must hesitate to say anything about them. It would be very

desirable indeed that they should be used either for making gas or firing boilers, provided they could be got cheap enough. However, it would take some time, for those things were of slow growth, perhaps, in the first instance due to people taking too sanguine a view of them.

Mr PRENTICE, referring to statements at top of p. 301 and again at the bottom, wherein Mr Aitken spoke of the superiority of the coke in these ovens over all others, asked in what particular qualities and properties the coke made in these ovens surpassed that made in an ordinary bee hive oven.

Mr HILL said that if the price of oil could be got even at double the cost of coal, in many cases for ships it would be a very great boon; because it would be worth while to pay a much higher price for fuel when they had to carry but half the quantity, and they would be able with a full quantity to take the steamboat twice the length that they could with their present supply of fuel. With regard to the steam ship, that would very likely before long become a large outlet for these oils. It would save not only the expense of freight in carrying extra fuel, but would be so much cleaner in working in the stoke hole, especially if made into gas.

The discussion was closed with a vote of thanks to Mr Aitken.

Mr HENRY AITKEN afterwards communicated the following :— Mr H. Aitken desires to make the following observations upon the remarks made by Mr Rowan. Mr Aitken in giving the heat units contained in oil and in coal, gave the average as stated in Dr. Clark's book, and he does not see the slightest reason for thinking that these figures are incorrect. On the contrary, he has learned since the meeting that the results got in firing steamers with oil in Russia, confirm the figures referred to, viz., —that one ton of oil is equal to two tons of coal. Undoubtedly there are differences in the heating power of both coal and oil; and Mr Rowan's statement, that eleven to twelve pounds of water have been evaporated per pound of coal used, may be quite true, but there is nothing said as to the kind of boiler used, or as to how much water this boiler would have evaporated if oil had been used. So far as Mr Aitken is aware, in Mr Sutherland's manner of working where he works the two producers in conjunction, the products of combustion and distillation

are taken at once to the furnace (after they have passed through the second producer) to be there consumed, and are not condensed and deprived of the oil and ammonia. Mr Sutherland's manner of working is quite different from Mr Aitken's, and the results obtained are equally different. The great advantage of the downward system of combustion and distillation is, that a larger quantity of more valuable hydro-carbons is obtained, and this, in Mr Aitken's opinion, will more than counterbalance any loss that may arise from the cooling down of the chamber. Referring to Mr Rowan's observations on the introduction of air at the sides of the producer, Mr Aitken would remark that his experience does not agree with Mr Rowan's as to the difference of the quality of gas produced where air is admitted at the sides of the producer, unless where the sides of the chamber are vertical. In a producer which Mr Aitken worked about ten years ago, the sides were at very much the same angle as that shewn in the Water Jacket Producer, and he found no difference in the quality of the gas made when the air was admitted at the sides, or when it was admitted into the centre through spaces in a brick building placed in the centre of the producer. The only advantage he found from admitting air at the centre (in the manner stated) in place of the sides, was, that he had less trouble with clinker. Air may be admitted in the bottom or sides as preferred. As to what grounds Mr Rowan has for supposing that the introduction of steam into the blast furnace would have a detrimental effect, Mr Aitken has no knowledge; but Mr Aitken may state that so far as his experience goes this would not be the case. The quantity of steam that will be put into the blast furnace is small, and is not admitted at the tuyeres, but above them; and this small quantity of steam is necessary to assist in the formation and protection of the ammonia, and in the elimination of the carbonic acid. Moreover, the steam, if desired, might be heated to any temperature required, and no cooling of the materials in the furnace would result. Referring to Mr Beilby's remarks, Mr Aitken has to observe that the analyses of the oils made by him, shewing the amount of paraffine which they contained, were made by a chemist of long experience in a Scotch oil work, and he feels

assured that these analyses are perfectly correct. Mr Aitken does not take the same view as to the use of the oils made when coking coal that Mr Beilby does. As to whether the gas companies will use these oils for making gas, that will be determined by the price, and if gas companies could be assured of a continuous supply at a small price, he has no doubt they would readily substitute oil for coal. Mr Prentice desires to know in what respects the coke made by Mr Aitken is superior to the coke made in other ovens. Mr Aitken answers this by saying that it is superior on account of its greater hardness, its possession of great strength and porosity, and because of the amount of work it performs.

EXHIBITION OF GAS PRODUCERS.

Mr F. J. ROWAN exhibited a series of drawings or illustrations prepared as magic lantern slides, and accompanied these by a short verbal description of each to illustrate the various steps in invention from the earliest attempts connected with the production of combustible gases. Commencing with views of close-topped blast furnaces, he referred to the various labours of Lampadius in 1801, Aubertot in 1809 to 1814, Victor Sire in 1836, and Faber du Faur in 1837, in the direction of the use of waste gases from blast and other furnaces. Bischof, in 1839, was the first to attempt the production of combustible gases by a separate generator or producer, of whose experiments we have any note. His producer was in shape like a blast furnace, but with an open grate, which necessitated its being placed at a lower level than the furnaces for using the gas. Ebelmen's plan (1841) resembled a blast furnace still more closely, having a closed hearth and blast of air introduced at the sides near the bottom. This produced gas under pressure, but it was found necessary to mix a flux with the fuel in order to run the ash and clinker into a slag and tap this out. Ekman's producer (1843), as illustrated by Dr. Percy, was worked downwards (the gases being taken off below), and had arrangements for utilizing the heat radiated from the body of the producer by

heating the air blast. The plan of M. Beaufumé (1856) was the first to propose a water jacketed producer, and a jet of steam introduced under the grate bars along with the air blast. The Siemens sloping grate producer, patented in 1861, was formed on the model of the "step-grate," and had a cooling tube leading from the upright stack by which the gases escaped from the producer. This method of cooling the gas was a novel feature, and it imparted greater density to the gases, and thus a descending column towards the furnace, while air was thus drawn slowly upwards through the grate. A modification of this producer to use sawdust fuel was introduced by Lundin in Sweden about 1863, and this plan was remarkable as being the first in which producer gases were washed and condensed before being used. The interesting design introduced by Mr Benson in 1868 provided means for the producer generating its own steam for the jets admitted into the incandescent fuel, and a movable iron bottom plate with spikes to break up and remove clinker and ashes. In this year (1868) M. E. Minary introduced in France two forms of gas producers; one with grate bars and a closed ash pit, into which air and steam were forced; and one with a closed hearth worked by air blast, and having the ash and clinker tapped out as slag. Wittenström's forced combustion chamber, which was really a gas producer, was patented in this country in 1871, but had previously been worked in Sweden. It was used successfully in what was termed the "Lancefield" furnace, but ultimately was thrown out, because the proper action of the producer depended upon regularity in the continuous feeding of the fuel, and it was impossible to secure this while the feeding was done by hand as proposed by the inventor. An improvement on this plan, by which mechanical feeding was substituted for hand feeding, was patented by Mr Rowan in 1876, for application to marine and other boilers. Kidd's generator (1874) was the first of those which were intended to make "water-gas," and in this line the Lowe (1874) and the Strong (1877) apparatus follow, although the latter have an intermittent method of working peculiarly their own. The Wilson producer (1876) was the first to use a steam jet as the means of forcing in air, with a closed hearth, in the centre of which the blast was admitted. It had

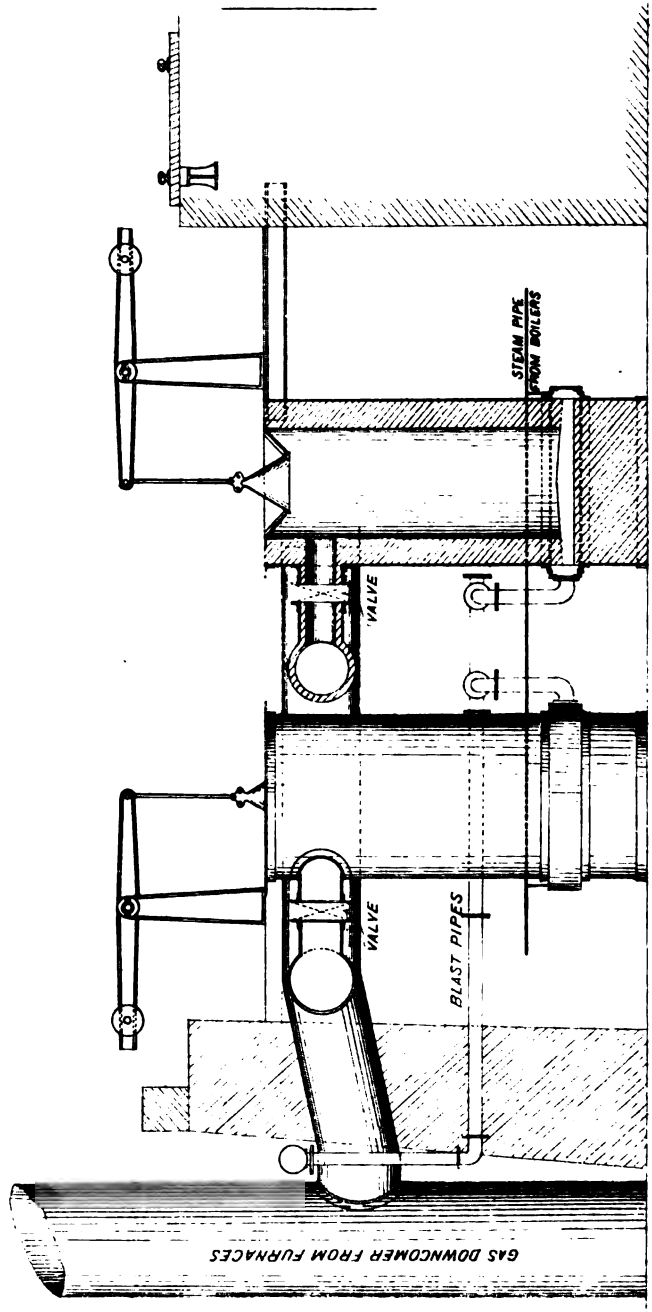
also an upper or "retort" portion, the object of which was to coke the fuel by the heat of the gases generated in the lower part. The new Wilson plan (1882) was the first providing automatic appliances for mechanical cleaning, and a means of recovering waste heat from the ash and clinker, in the water trough below. In France a producer, worked by Berard in 1866, but improved by Tessié du Motay, whose name it bore in 1879, was used in one or two works. As improved by Tessié it had a series of channels across the hearth or bottom, terminating in cast iron boxes into which the branches from the blast pipe led. The ash and clinker were pushed through these channels, the doors of these boxes being opened for this purpose. Dowson's producer (1878-81) was similar to Wilson's, but on a smaller scale, and with Benson's movable grate bottom instead of a closed hearth. The producer of Gröbe and Lurman (1880) provided two chambers, one for coking the coal, and one for burning the coke to carbonic oxide. Sutherland's original plan (1878) had no very marked features, but his later one (1883) showed two producers working together, the gas from the one being passed through the other, and vice versa; a regenerative chamber of fire-brick being also combined with each producer. The reversing of the currents of gas and air was accomplished by a slide-valve form of reversing valve—this form was, however, introduced by M. Witterström in 1875. The Siemens new producer (1881) seemed to have been anticipated by one published by Mr Healy in 1872. The plans of Young and Beilby, so lately described by Mr Beilby, possess features of great importance and interest in connection with this subject.

In addition to these designs of gas producers, the following illustrations of furnaces were shown:— Crampton's coal-dust furnaces and appliances for feeding in the coal-dust and air, Gorman's heat restoring furnace with its producer, the Ponsard furnace with its recuperator, and the Boetius, Bicheroux, and Casson Dormoy furnaces, which like it, make use of a form of the Siemens sloping grate producer. Plans of Price's retort were also shown.

On the motion of the President, a vote of thanks was awarded to Mr Rowan for the interesting exhibition and description.

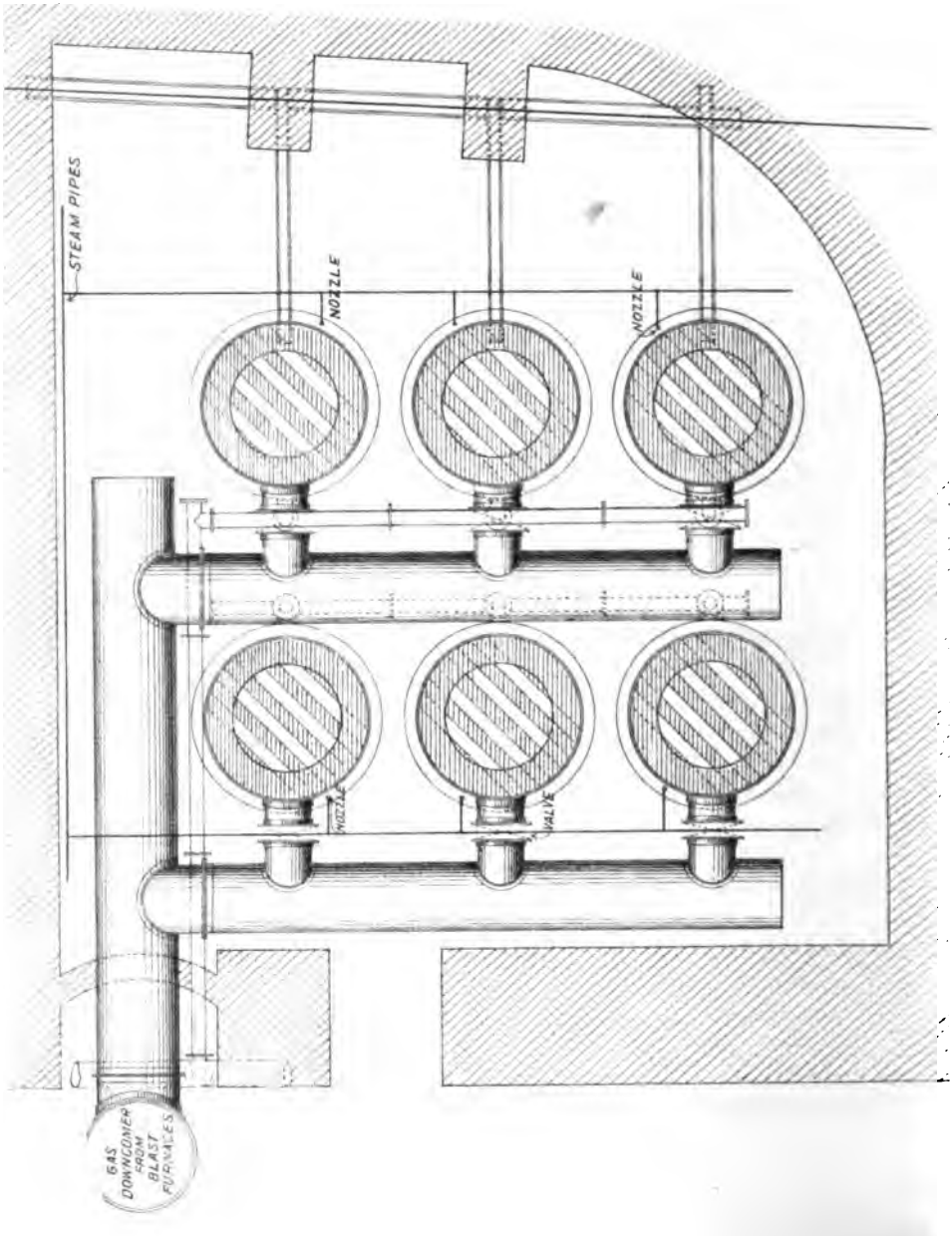
GAS PRODUCERS AT CARRON IRON WORKS.

TO ILLUSTRATE MR D. COWAN'S DESCRIPTION.



GAS PRODUCERS AT CARRON IRON WORKS.

TO ILLUSTRATE Mr D. COWAN'S DESCRIPTION.



DESCRIPTION OF ARRANGEMENTS IN COURSE OF COMPLETION FOR THE APPLICATION AND DISTRIBUTION OF GASEOUS FUEL AT CARRON IRON WORKS.

By DAVID COWAN, Manager for Carron Company.

These works embrace an area of about 25 Acres, and are divided into the following sections :—

Section I.—BLAST FURNACES.
„ II.—LOW OR LIGHT FOUNDRY.
„ III.—HIGH OR HEAVY FOUNDRY.
„ IV.—BRICK WORKS.

The waste gases from the blast furnaces are collected in the usual way by covering their tops and leading the gases through down-comer pipes into a horizontal main, from which branches are led to the blast furnace, air-heating stoves, and the steam boilers which actuate the several blowing engines.

From the blast furnace section the gas mains are prolonged into the low foundry, and after passing through it, are carried on to, and past the high foundry to the brickworks.

Branches are led from the same main to the enamelling kilns, the foundry steam boilers, kilns or fire-places for drying ladles for distributing molten iron, core stoves for igniting cupola furnaces, and to the furnaces of the kilns for burning bricks and drying stoves in connection therewith.

The total length of the gas mains is about 2700 feet. The brickworks are situated at the point most distant from the blast furnaces, about 1320 feet. The whole is being so arranged that no coal will be used in the works except such as is charged into the blast furnaces.

In the event of the blast furnaces being at any time put out of blast, or should there be from any other cause any insufficiency of gas, a nest of gas producers is provided and placed in communication with the gas mains.

The annexed sketches (Plates XXII., XXIII.) shew the arrangement and construction of these producers. Referring thereto, it will be seen that the producers are of the very

simplest kind. Each consists of a wrought iron cylindrical casing lined with fire brick. Near to the bottom, each producer is encircled by a belt into which is introduced an air and a steam blast. The air and steam enter the producer through six tuyeres, three on each side, arranged diametrically opposite, so that a poker can be passed right through and through the bottom of the incandescent coal. At right angles to the tuyere openings are two doors, one on each side of either producer, which can be removed at any time to give access to the interior.

In this case a considerable pressure of blast is necessary to counterbalance the pressure in the gas tubes due to the engines blowing the furnaces.

Careful experiments were made to determine the best form for applying the gas to the several operations; and this having now in a large measure been determined, it is expected that the whole will be completed in a few months.

NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES.

VIBRATION, OR THE EFFECT OF PASSING TRAINS ON IRON BRIDGES, MASONRY, AND OTHER STRUCTURES, by James L. Randolph. Transactions of the AMERICAN SOCIETY of CIVIL ENGINEERS, Vol. XII., P. 444.—The author here gives his experience gained in connection with one of the American Railroads, and states certain theories of the cause of movement of the stones in bridge piers, and his efforts to present such. He attributes the failure of certain double track bridges to maintain their rigidity and original form to the twisting action produced by the strain of passing trains being always in one direction on the same side of the bridge. The displacement of the stones of piers, and even of the piers themselves, are caused by the vibrations due to passing trains being transmitted irregularly in time and direction by the stones of varied size and, where rough dressed ruble, of varied shape. Where iron and stone are in conjunction in the piers of a bridge, the author is of opinion, that, being of different elasticity, and consequently vibrating in different times, they, during vibration, lose contact for indefinitely short intervals of time, and allow small misplacements to occur. These movements may be cumulative, and after an interval of time may be very serious indeed—in one case mentioned, four inches in four years. A piece of two-inch plank placed between the iron and the stone appears to have prevented any movement in the subsequent four years. It is argued, to account for this simple contrivance being effective, that the wood is of different elasticity, and its period of vibration also different from both stone and iron, and it consequently retains contact with both continuously. The author has set all his iron bridges of 100ft. span and under on wooden wall plates; and, where sufficiently under water to insure its being always wet, has even placed a platform of timber under piers and other masonry carrying an iron superstructure with the result that no movement has ever been observed in such cases.

J. H.

TRANSACTIONS of the AMERICAN SOCIETY of CIVIL ENGINEERS—THE COST of STEAM POWER, by Charles E. Emery, Ph.D., Vol. XII., P. 425. The table attached to this paper is its essential feature—the paper itself being indeed devoted to the explanation of the table. The table was originally made up for use in a law suit arising out of a claim by mill owners for loss of water power by diversion of part of the natural flow of a river. The cost of steam power per horse power per year is set forth in detail, and the capitalized value in perpetuity, including renewal for various sizes of

Engines calculated. The following extract from the table will exhibit the results and several of the peculiar features more clearly and concisively than can be done in words.—

Dynamometric Horse-Power.	Kind of Engine.	Cost of Coal per H.-P. per year at $4·17 per Ton.	Total Cost per H.-P. per year of 300 days.	Total Cost of Operating and Current Expenses exclusive of Coal per H.-P. per year.
		Dollars.	Dollars.	Dollars.
5	Portable, Upright, ...	131·13	45·33	176·46
10	,, ,, ...	68·72	41·24	109·96
15	,, ,, ...	52·25	37·89	90·14
20	,, Horizontal, ...	40·92	32·36	73·28
25	,, ,, ...	37·18	30·10	67·28
50	Stationary, Non-Condensing,	28·09	24·06	52·15
100	Condensing, Single, ...	17·04	18·98	36·02
150	,, ,, ...	13·01	18·12	31·13
200	,, ,, ...	10·62	18·02	28·64
250	,, ,, ...	9·50	18·02	27·52
300	,, ,, ...	8·80	18·02	26·82
400	,, ,, ...	7·99	18·02	26·01
500	,, ,, ...	7·64	18·02	25·66

The third column includes all expenses, except coal and interest on capital. Taxation and insurance at a half per cent. of cost of engine are included.

The author says—"The result shews that steam power in sufficient quantity may be maintained for ever by an outlay of $660 per horse power, a portion of which would be expended for plant, and the balance invested to provide for operating expenses and renewals." This is calculated upon the basis of current prices in January, 1874, allowing for renewal every thirty years, and current expenses capitalized at six per cent. J. H.

The Journal of the BRITISH SOCIETY OF MINING STUDENTS. Vol. VII., Parts 1 to 4.—Although this Society adopts the name "British" there is only one Scotch address in its list of 230 members. It appears during the past year to have been in a languishing condition, which is to be regretted, as its objects are laudable; and it should quickly revive on taking means to make itself more generally known. Members must be students of mining engineering, and under 25 years of age, or working men employed in collieries; there are also senior and honorary members. Some of its rules are peculiar; rule 7 runs "each member shall be supplied with the names and addresses of the other members, and may write and ask questions of them, even if not personally acquainted;" and rule 16 says that "every member of the society shall, on receiving two months' notice from the secretary, send a contribution to the Journal; failing to comply with such notice, his name shall be brought forward at the next general meeting."

Among other papers, the Journal contains (Part 3) an able and exhaustive article on COLLIERY WINDING ROPES AND THEIR ATTACHMENTS TO THE CAGE, in which the materials from which ropes of the hemp class are manufactured are first described;

and the nature of combination ropes of Russian and Manilla hemp, which are found in the writer's experience to last twice as long as ordinary Russian hemp ropes, is discussed. As mines increased in depth hemp became unavailable, as 240 to 300 fathoms of its length is equal in weight to its working load; and iron wire ropes were introduced into the Hartz in 1830, but not into this country till ten years later. But an iron wire rope is strained to its working load with 415 fathoms of its own length, so something stronger was required for such mines as Ashton, near Manchester, which is 448 fathoms deep, and in 1860 steel was introduced in the manufacture of ropes and has been gradually increased in tenacity until now plough steel has a breaking strain of 120 tons per square inch. For great depths ropes are lightened by making them tapered, and in this paper the taper ropes employed in the Adelbert silver mine in Bohemia (612 fathoms deep) are described. They consist of 36 wires manufactured from steel having a tenacity of 72 tons per square inch, the taper being given to the rope by reducing the gauge of the wires from ·108 inch diameter at the drum end to ·075 inch at the cage. It appears that these ropes can now be manufactured almost as easily as the ordinary kind.

The construction of ropes is next dealt with; the hawser, shroud, and cable laid forms of hemp ropes are described; then the original selvagee rope which consists of a bundle of iron wire laid parallel and bound together; and the laid and compound forms of wire rope in use at the present day. Among the later forms of ropes are mentioned Lang's patent, in which the wires and strands are both twisted in the same direction, thus giving a much longer surface of wire exposed to fricton which lessens the risk of individual wires breaking at the crown of the strands; and also a new form of rope made in Switzerland in which coarse cotton yarn is spun about the separate wires so that a soft bed is obtained between them and soft rest for the whole rope; this rope is said to be very durable, and not liable to rust. The author does not approve of wire centres which are liable to break when the rope stretches; hemp centres on the other hand stretch with the rope and allow the strands to bed themselves solidly. He gives short empirical rules for finding the weight and strength of ropes, and shows that the strength may also be calculated in a rational manner from the sectional area of the wires and the tenacity of the material of which they are composed, and deducting $\frac{1}{5}$th for the loss of strength due to the lay.

In dealing with the duration of ropes he recites some good practice, viz.:—The size of drums should be 10 feet diameter for a rope 1 inch in circumference, adding 6 inches to the diameter for every additional $\frac{1}{4}$ inch in circumference, pulleys should be the same size. The incline portion of rope, from pulley to drum, should not make an angle of less than 45 degrees with the rope in the pit, and it should never deviate further from the plane of the pulley than $\frac{1}{10}$th of the distance between the pulley and drum shafts. Ropes should not be shifted from one drum to another even although larger, and there is no saving in turning them end for end. Excessive wear of that part of the rope which is over the pulley when moving the cage at bank should be avoided by re-capping which at some collieries is done every six months.

Roughly, he finds iron wire ropes to last one year, crucible stee $1\frac{1}{2}$ years, patent steel 2 years, and plough steel ropes $2\frac{1}{2}$ years. A table is given showing all the details of several ropes, the number of months they lasted and the tons of coal drawn, from which it appears that the cost per ton for winding ropes varied from ·07d. to ·30d. per ton.

Treating of the connections of the rope to the cage, the writer remarks that the working parts of detaching hooks are liable to rust together, especially those composed of plates, and that it is desirable to keep a spare one and overhaul them every three months.

The capping of ropes is elaborately entered into, and tables of experimental results are given which are very suggestive. The hooped form gives the best results, and even these on a rope having a breaking strain of 60 tons had the rope drawn from 2 inches to $2\frac{3}{4}$ inches out of them with a strain of 25 tons. In three of the experiments, the rope broke inside the cap with a strain of from $44\frac{1}{2}$ to 49 tons, shewing that the cap or hose is the weakest part. J. G.

In the Transactions of the MANCHESTER GEOLOGICAL SOCIETY, Vol. XVII., Part XII., there is a paper by Mr George Wild on SIGILLARIA ("POT-HOLES") AND THEIR DETECTION IN THE ROOF OF A COAL SEAM by their Stigmarian Roots.

"Pot-bottoms," which drop out of the roof of coal seams, are a source of considerable danger. It has been suggested that some of them have originated by bubbles forming at the surface of the liquid mass of matter during the formation of coal, bursting and allowing the soft covering of muddy sediment to run into them, and so forming casts of shale, &c., surrounded by thin films of carbonaceous matter. However that may be, many of them, as the writer of this paper shews, are really casts of the trunk of Sigillaria filled in with the substance composing the roof, and, being separated all round by a thin film of organic matter, are liable to drop out immediately the coal under them is removed. He finds that the presence of these trunks is often indicated by the punctures of Stigmaria, the root of Sigillaria, below them; and also by the roots themselves bearing towards one centre, where the trunk is. These roots may be recognized by the shale inside being generally of a lighter colour than that which surrounds them. The coal itself under these pot-holes is also generally tough or woody, its cleavage having been disturbed.

J. G.

"COLLIERY EXPLOSIONS IN PRUSSIA in the Years 1868 to 1881, and in other Coal Producing Countries of Europe," by Chas. Z. Bunning.—SOUTH WALES INSTITUTE OF ENGINEERS, No. 6, Vol. XIII.

A translation of a report prepared from official sources for the Prussian Royal Fire-Damp Commission, giving very complete statistical tables showing the number of explosions and other accidents in Coal Mines throughout Prussia from 1852 to 1881.

H. B. M.

Proceedings of the MINING INSTITUTE OF CORNWALL, Nos. 1, 2, 3, 5, 6, 7, and 8, Vol. I. 1882.

The subjects treated of in these numbers embrace a wide field. Stamping, Jigging, Winding, and Pumping Machinery, and dressing and treating of Tin Ores, supply subjects for several papers of great practical value to those interested in or associated with Cornish mining affairs. Subjects of considerable social importance are found in papers on a Permanent Club and Relief Society proposed for Cornwall and Devon, Mining as an Industry, Technical Education of Miners, Smoke in relation to the Health of Miners; whilst subjects of general interest to miners are found in papers on Ventilation, Mining Explosives, Duty of Cornish Engines, Stone-breakers, and Rock Drills.

These papers are all ably written and very fully discussed, and are accompanied by clear and detailed illustrations where necessary. It is to be noted that, like all our technical papers, the Cornish Transactions are open to the objection of too freely using technical phraseology, which often is greatly misunderstood or totally unknown outside the locality in which they are used.

Two most interesting papers, which well repay perusal, are these—"Tin Fields of Tasmania," by Mr John Mufford, and "Lodes of the Sierra Almagrera in the South of Spain," by Mr Frecheville, H. M. I. of Mines. They are short, but abound in most interesting information and facts.

G. B. B.

ON A NEW VENTILATING FAN.—On the 4th January last, Mr C. Cockson, M.E., read a paper before the MANCHESTER GEOLOGICAL SOCIETY on Centrifugal Fans, their relative efficiency and useful effects; in which he describes an improved type of the Guibal Fan lately designed and patented by him. This fan, which possesses all the advantages of the ordinary Guibal, is like the Schiele a silent non-vibratory one.

The fan which is erected at the Dairy Pit, belonging to the Wigan Coal and Iron Coy., is of this description:—"It is 30 feet in dia., has a close-fitting casting, expanding chim-"ney, and adjustable shutter just like the Guibal, but the blades of the fan are made to "taper from a width of 15 feet at the inlet end of blade to a width of 7 feet at the tip—"this tapering of the blades being so proportioned as to give an equal area of air passage "throughout the fan, and it is in this that the main alteration lies, and it is owing to "this that the fan is a silent one. This particular fan draws its air through one inlet 14 "feet in diameter, the fan being connected to the upcast by a circular iron tube of that "size. The upper half of the fan-casting is made of iron plates cast to the outline of "the curve of the blades and roofed with wood logs, while the lower half and fan race "and chimney are built in brickwork to the same curve."

This fan passes 250,000 cubic feet of air per minute at 80 revolutions, with a w.g. of 4·9 inches. It is not directly coupled to the engine, but is attached to it with cotton ropes running in grooved pulleys.

Although this fan has a diameter of 30 feet, still, according to Mr Cockson, fans of the above type, from 12 to 20 feet in diameter, with the same blade speed, are capable of passing as much air per minute as an ordinary Guibal of from 30 to 50 feet diameter. The patentee, moreover, asserts that on account of its small size and weight it is less costly in its erection, is less liable to injurious straining, and gives a higher water guage and a larger quantity of air than the Schiele, with even a less speed; and that, yielding 70 per Cent. of useful effect, it is consequently the cheapest, most efficient, and most economical fan yet invented. J. HR.

THE PIELER PIT GAS INDICATORS.—Dr. C. Le Neve Foster brought before the Members of the MANCHESTER GEOLOGICAL SOCIETY, on 5th February last, Herr Pieler's methods of determining the percentage of fire-damp and carbonic acid gas in the atmosphere of mines.

By means of a cylindrical aspiration above ground connected with a tube to the upcast air of the pit he obtained a fixed quantity of mine air, which he tested for fire-damp by contact with a hydrogen flame.

In his underground method he substituted for the hydrogen lamp a suitably altered "Davy" supplied with spirits of wine. Above the burner there is fixed a converging chimney one and one-fifth inches high which serves to regulate the height of the flame during testing. By experiment this lamp appears to be exceedingly sensitive to the presence of gas. With one fourth per cent. of fire-damp the flame is slightly luminous, and with one-half per cent. it shews a clearly recognisable cap, which deepens in colour and length as the percentage increases.

The quantity of carbonic acid is ascertained by allowing this gas in a fixed quantity of pit air to pass through a solution of potash. J. HR.

THE

MINING INSTITUTE

OF

SCOTLAND.

RULES.

LIST OF MEMBERS, 1883-84.

CATALOGUE OF LIBRARY.

HAMILTON: PRINTED BY WILLIAM NAISMITH.
1884.

THE MINING INSTITUTE OF SCOTLAND.

RULES,

AS REVISED AT THE ANNUAL MEETING,

12th April, 1883.

SECTION I.—OBJECTS.

1.—The objects of this Institute are to enable its Members to meet together at fixed times to discuss the means for the Ventilation of Coal and other Mines, the Winning and Working of Collieries and Mines, the Prevention of Accidents, and the Advancement of the Sciences of Mining and Engineering.

SECTION II.—CONSTITUTION.

1.—The Institute to consist of Ordinary Members, Life Members, and Honorary Members.

2.—The Council of the Institute for the management of its affairs shall be chosen annually from the Members, and shall consist of a President, Four Vice-Presidents, Twelve Councillors a Secretary, and a Treasurer.

SECTION III.—QUALIFICATION OF MEMBERS.

1.—Ordinary Members to be persons practising as Colliery Managers, Mining, Civil, or Mechanical Engineers, and other persons connected with, or interested in, Mining and Engineering of whom the Council may approve.

2.—Life Members to be persons who shall compound for all future payments by a payment of Ten Guineas, or on such conditions as the Council may in writing accept.

3.—Honorary Members to be persons of whom, although not technically qualified, the Council may approve.

Section IV.—Election and Expulsion of Members.

1.—A recommendation for admission, according to Form A, in the Appendix, to be forwarded to the Secretary, and by him to be laid before the next meeting of the Council. The recommendation to be signed by Two Ordinary Members or Life Members.

2.—The Election to take place at a General or Special Meeting by ballot; three-fifths of the votes tendered being necessary for election.

3.—In the case of non-election, no mention thereof shall be made in the minutes, nor any notice given to the unsuccessful candidate.

4.—When the proposed candidate is elected, the Secretary shall give him notice thereof, according to Form B., but his name shall not be added to the list of Ordinary Members or Honorary Members until, and unless, within two months after notice of election as above, he shall have paid his first annual subscription, and signed the Form C., whereupon he shall be entitled to all privileges of Membership, including a copy of the Transactions issued in that year.

5.—The Transactions of the Institute shall not be forwarded to persons whose subscriptions are more than six months in arrears.

6.—Any person whose subscription is twelve months in arrear shall be reported to the Council, who shall direct application to be made for it, according to Form D.; and in the event of its continuing one month in arrear after such application, the Council shall have the power, after suitable remonstrance by letter, in the form so provided (Form E), of erasing the name of the defaulter from the register of the Institute.

Section V.—Election of Officers.

1.—The election of Officers shall take place at the Annual General Meeting in the month of April in each year.

2.—The President, the Vice-Presidents, and Councillors to retire annually; but they shall be eligible for re-election with the exception of one Vice-President and the three Councillors who may have attended the fewest Council Meetings during the past year, and when such attendances are equal, the Council shall decide which of the Vice-Presidents and Councillors shall be re-nominated; but such persons shall be eligible for re-election after being one year out of office.

3.—Candidates to be put in nomination at the General Meeting preceding the Annual General Meeting, when the Council shall present a list of their retiring members who offer themselves for re-election. Any member to be entitled to add to the list of Candidates. In case of the decease or resignation of any Officer or Officers, notice thereof must be given at the next General or Special Meeting, and a new Officer or Officers elected at the succeeding General or Special Meeting, in accordance with the mode above mentioned.

4.—The Secretary and Treasurer shall be appointed every year by the Council, at the first meeting of the Council after the Annual General Meeting.

Section VI.—Meetings.

1.—There shall be Nine Ordinary General Meetings in each year, to be held in Hamilton, unless elsewhere arranged for by the Council. The Annual General Meeting to be held in the month of April.

2.—A Special Meeting of the Institute to be called whenever the Council may think fit, and also on a requisition to the Council distinctly specifying the reason thereof, signed by ten members.

3.—The Ordinary Members, Life Members, and Honorary Members to have notice of, and the privilege to attend all General and Special Meetings, but Ordinary Members and Life Members only to be entitled to vote on any question by ballot or otherwise.

4.—Every question, not otherwise provided for, which shall come before any Meeting of the Institute, shall be decided by the votes of the majority of the Members and Life Members then present. But the Council shall have the discretionary power of suspending the effect of such decision, if by them considered to be prejudicial to the interests of the Institute; and of referring the same to a special or to the next General Meeting, and at least ten days before such meeting, the Secretary shall have sent, by printed circular, to every person enrolled in the Institute, explicit notice of the question in abeyance.

5.—Invitations shall be forwarded by the Council to any gentleman whose presence at the discussion they may think advisable; and strangers so invited shall be permitted to take part in the proceedings, but not to vote.

6.—Any person enrolled in the Institute shall have power to introduce a friend or stranger (see Form F) to any of the General Meetings of the Institute, but such visitor shall not take part in the proceedings, except by permission of the meeting.

7.—No alteration of the Rules to be made at any but the Annual General Meeting, or at a Special Meeting for that purpose; and the particulars of every such alteration shall be announced at a previous General Meeting and inserted in the minutes; and such Annual or Special Meeting shall have power to adopt any modification of such proposed alteration of, or addition to, the Rules.

Section VII.—Subscriptions.

1.—The annual Subscription of each Ordinary Member shall be 10s 6d, excepting Coalmasters, Agents, Civil, Mining, and Mechanical Engineers, and other Members interested in but not actively engaged in Mining, whose Subscription shall be £1 1s.

2.—All Annual Subscriptions to be payable in advance, and the same are to be considered due and payable at the April meeting of each year, or immediately after election.

Section VIII.—Communication by Members.

1.—All papers shall be submitted to the Council fourteen days before the date when it is proposed that they be read, and the Coun-

cil shall have power to decline any papers. The Council shall direct whether any paper read before the Institute shall be printed in the Transactions; and notice shall be given to the writer within one week after it has been read, whether it is to be printed or not.

2.—The Council shall have the power to publish any or all of the communications as they may think proper.

3.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use, and such a further number given him at cost price as may be approved of by the Council.

4.—All proofs of discussion, forwarded to persons who have taken part therein for correction, must be returned to the Secretary within two days from the date of their receipt, otherwise they will be considered correct and be printed off.

5.—The Institute is not, as a body, responsible for the facts and opinions advanced in the papers which may be read, and in the discussions which may take place at the meetings of the Institute.

The copyright of all papers communicated to, and accepted for printing by the Council and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise without the written permission of the Council.

SECTION IX.—DUTIES OF THE OFFICERS AND COUNCIL.

1.—The President to be Chairman at all Meetings, and, in his absence, one of the Vice-Presidents. In the absence of a Vice-President, the Members present to elect a Chairman for that Meeting.

2.—The Funds of the Institute shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

3.—The Secretary shall be present at all the Meetings, and shall take minutes of the proceedings and read those of the preceding Meeting; but, in the case of unavoidable absence, the Council to appoint some one to act for him.

4.—All past Presidents shall be *ex officio* Members of the Council so long as they continue Members of the Institute; and Vice-Presidents, not re-elected, shall be *ex officio* Members of the Council for the following year.

5.—At Meetings of the Council five shall be a quorum, and the minutes of the Council's proceedings shall be at all times open to the inspection of the Members of the Institute. The President shall be *ex officio* chairman of every committee.

6.—The Council shall have power to revise and correct proofs of communications and the discussions thereon, and to delete any portion or portions of the discussion which may be by them deemed unsuitable for publication.

7.—At the Annual General Meeting the Council shall present a report of the proceedings, and an abstract of the accounts of the previous year, audited by Two Ordinary Members who are not Members of the Council.

Section X.—Property of the Institute.

1.—All the Property of the Institute to be held by the Council in trust for the Institute.

2.—All Books, Drawings, Communications, &c., shall be accessible to all the Members of the Institute; and shall be held in trust by the Council, at the Rooms of the Institute in Hamilton, for the use of the Members.

3.—None of the property of the Institute, as Books, Drawings, &c., to be taken out of the Rooms of the Institute without the consent of the Council.

4.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members or others, unless by written order from the Council.

5.—All donations to the Institute shall be enumerated in the annual report of the Council to the Members.

Section XI.—Disputes.

1.—Any difference of opinion arising regarding the interpretation of any of the foregoing Rules to be submitted to the Council, whose decision shall be final.

BY-LAWS.

I.—The General Meetings to be conducted, as far as practicable, in the following order:—

1st.—The Chair to be taken at Six p.m.

2nd.—The minutes of the previous meeting to be read by the Secretary or person appointed, and, after being confirmed, to be signed by the Chairman of that meeting.

3rd.—The balloting of new nominations for membership shall be proceeded with and the result announced.

4th.—Communications by letter to be read by the Secretary, according to priority of date.

5th.—Communications from the Council to be read by the Secretary.

6th.—Discussion will be invited upon a paper or papers read at a previous meeting, copies of which, if printed, will have been circulated among the members.

7th.—The paper or papers announced for the meeting will be read.

8th.—With a view to the maintenance of order during discussions, and to prevent them from degenerating into mere conversations, no remarks will be considered in order unless the speaker is standing.

II.—Any member changing his residence to give notice in writing to the Secretary.

APPENDIX.

[FORM A.]

Name in full, Mr

Designation or occupation,

Address,

being desirous of admission into the Mining Institute of Scotland, we, the undersigned, propose and recommend that he shall become a thereof.

Proposed by { } Signature of two Members.

Dated 18

See Rules
Section III.—Qualification of Members.
Section IV.—Articles 1 and 2.—Election of Members

[FORM B.]

SIR,—I beg to inform you, that on the day of you were elected a of the Mining Institute of Scotland; but, in conformity with its Rules, your election cannot be confirmed until the enclosed form be returned to me with your signature, and until your first annual subscription of £ , be paid.

If not paid within two months from this date, the election will be void, under Rule 4, Section IV.

I am, Sir,

Yours faithfully,

Secretary.

Dated, 18

[FORM C.]

I, the undersigned, being elected an of the Mining Institute of Scotland, do hereby agree that I will be governed by the regulations of the said Institute as they are now formed, or as they may be hereafter altered; that I will advance the objects of the Institute as far as shall be in my power, and

will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can, provided that whenever I signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period), be free from this obligation.

Witness my hand this day of

Signature.

[FORM D.]

I am directed by the Council of the Mining Institute of Scotland to draw your attention to Rule 6, Section IV., and to remind you that the sum of £ of your annual subscription remains unpaid, and that you are, in consequence, in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay.

I am, Sir,

Yours faithfully,

Secretary.

Dated, 18

[FORM E.]

SIR,—I am directed by the Council of the Mining Institute of Scotland to inform you that in consequence of your arrears of subscription, and in pursuance of Rule 6, Section IV., the Council have declared by special vote, on the day of 18 , that you have forfeited your claim to belong to the Institute, and your name will be, in consequence, expunged from the Register, unless payment is made previous to 18

I am, Sir,

Yours faithfully,

Secretary.

Dated, 18

[FORM F.]

Admit
of
to the Meeting on Thursday, the
Signature of Member
The chair to be taken at Six P.M.

I undertake to abide by the regulations of the Mining Institute of Scotland, and not to aid in any unauthorised publication of the proceedings.

Signature of Visitor.

Not transferable.

The Mining Institute of Scotland.

1883-84.

HONORARY MEMBERS.

	Year of Entry.
ALEXANDER, WILLIAM, H.M. Inspector of Mines, 23 India Street, Glasgow,	1878
MOORE, RALPH, H.M. Inspector of Mines, Croft Villa, Rutherglen *(Past President)*,	1878

ORDINARY MEMBERS.

Subscription, £1 1s.

Abraham, David, Dowlais Iron Works, Glamorgan,	1883
Adams, James, Hill of Beath, Fife,	1880
Aitken, Henry, Darroch, Falkirk,	1878
Anderson, David, Clydesdale Street, Hamilton (Vice-President),	1879
Anderson, George, Ashgrove Villa, Airdrie,	1880
Anderson, James, Farme Colliery, Rutherglen,	1880
Arrol, Arthur T., 16 Dixon Street, Glasgow,	1879
Austine, John, Oak Lodge, Hamilton (Member of Council),	1878
Baird, Archibald, Park Road, Hamilton,	1879

Baird, Matthew B., Charleville, Uddingston, - - 1880
Baird, Robert, 141 St. Vincent Street, Glasgow, - - 1879
Barr, James, Longlee Colliery, Larkhall, - - - 1879
Barr, William, Over-Dalserf Colliery, Larkhall, - - 1879
Barrowman, James, Portland Park, Hamilton (Secretary), 1879
Begg, Gilbert Burns, Brandon Street, Motherwell (Past President), - - - - - 1878
Beilby, George, Mid Calder, - - - - 1884
Bell, James, San Fermin Mining Company, Portugalete, Bilbao, - - - - - - 1881
Birrel, George, Dunfermline, - - - - 1880
Bishop, George A., Royal Bank, Coatbridge, - - 1879
Blackadder, Alexander, Stand Colliery, Airdrie, - - 1880
Borland, Thomas, Clyde Iron Works, Tollcross, Glasgow, 1880
Brand, A. Douglas, 6 Dixon Street, Glasgow, - - 1881
Brown, Thomas M., Lanemark Colliery, New Cumnock, - 1880
Buchanan, D. C. R. C., Drumpellier, Coatbridge, - - 1881

Cameron, Robert, Priory Lodge, Blantyre, - - 1879
Campbell, Archibald, Redding Collieries, Polmont Station, 1883
Carlow, Charles, The Fife Coal Company, Leven, - - 1879
Chambers, William, Dalziel Saw-Mills, Motherwell, - 1880
Clark, James, Linrigg Colliery, Cleland, - - - 1880
Clark, Robert, Arniston Colliery, Gorebridge, - - 1883
Clark, William, 95 Bath Street, Glasgow, - - 1883
Colquhoun, James, Tredegar Iron Works, South Wales, - 1882
Connal, John, 123 St. Vincent Street, Glasgow, - - 1882
Cook, William, Germiston Street, Glasgow, - - 1884
Cowan, David, Carron Iron Works, Falkirk, - - 1879

Crossley, William, 153 Queen Street, Glasgow, - - 1881
Cuninghame, Alex., Carnbroe Iron Works, Coatbridge, - 1880
Cuninghame, J. C., 127 St. Vincent Street, Glasgow, - 1879
Cuninghame, John, 127 St. Vincent Street, Glasgow, - 1879
Curry, William T., Usworth Colliery, Co. Durham, - 1883

Dalzell, John B., Hill Colliery, Lesmahagow, - - 1881
Darling, John, Cleugh Gas Coal Works, Forth, Lanark, - 1880
Dick, James,* Knownoble, Wishaw, - - - 1881
Dixon, James S., Bent Colliery, Hamilton (Vice-President), 1879
Duncan, Frederick, 5 Clarinda Terrace, Pollokshields, - 1879
Dunn, David G., Collingwood, Aytoun Road, Pollokshields, 1882
Dunn, John, Bothwell, - - - - - 1881
Durie, John, Elphinstone Colliery, Tranent, - - 1880

Fraser, William, Pumpherston Oil Co., Uphall, - - 1881
Frew, Robert, 75 Bath Street, Glasgow, - - - 1879
Frew, William, Raploch Colliery, Larkhall, - - 1880

Galloway, John, Ardrossan, - - - - 1879
Galloway, Robert L., 98 West George Street, Glasgow, - 1884
Galloway, T. Lindsay, Argyll Colliery, Campbeltown, - 1880
Gardiner, David, Meiklehill Colliery, Kirkintilloch, - 1881
Geddes, G. H., 142 Princes Street, Edinburgh, - - 1881
Gemmell, John, 96 New City Road, Glasgow, - - 1883
Gilmour Allan, Portland Colliery, Kilmarnock, - - 1879
Gilmour, Daniel, Portland Colliery, Kilmarnock, - - 1881
Gilmour, James, Duchray Colliery, Coylton, Ayr, - - 1881

* Deceased.

Gilmour, Joseph, Goatfoot Colliery, Galston, - - 1881
Glen, Robert, Eastfield Colliery, Cambuslang, - - 1881
Grainger, W. N., 15 Hanover Street, Edinburgh, - - 1879
Grant, T. M., Townholm Engine Works, Kilmarnock, - 1879
Gray, Archibald, Middleton House, Dalry, Ayrshire, - 1883
Gray, Archibald, Stanley Bank, Dalry, - - - 1881
Gray, John, Avon Cottage, Stonehouse, - - - 1882
Greig, John, Tillgrie, Milnathort, Kinross, - - 1879
Grierson, Thomas, Glebe Colliery, Douglas, - - 1881

Hamilton, James, 97 N. Frederick Street, Glasgow, - 1883
Hamilton, John G. C., Dalzell, - - - - 1881
Hamilton, Robert, - - - - - 1880
Hamilton, Thomas, 101 West Regent Street, Glasgow, - 1879
Henderson, Norman M., Broxburn Oil Works, Broxburn, 1884
Hendrie, John, 82 West Regent Street, Glasgow, - 1881
Hill, Alexander, Barrancos, Portugal, - - 1883
Hill, Laurence, 59 St. Vincent Street, Glasgow, - - 1883
Hodson, James, Liverpool Road, St. Helens, Lancashire, - 1880
Hood, Archibald, 6 Bute Crescent, Cardiff, - - 1879
Hurll, Mark, Glenboig, Coatbridge, - - - 1880
Hutchison, Joseph, Woodside Colliery, Dalserf, - - 1881
Hyslop, Jonathan, Kinneil Iron Works, Bo'ness, - - 1881

Irvine, C. M'Laren, Fence Colliery, Blackwood, Lesmahagow, 1880

Jack, Robert, Bank of Scotland, Motherwell, - - 1883
Jamieson, Alexander, Fairview Cottage, Bellshill, - 1878
Jenkins, James G., 33 Renfield Street, Glasgow, - - 1882

Johnstone, David, 12 York Street, Glasgow, - - 1881
Johnstone, Ronald H., 75 West Nile Street, Glasgow, - 1879
Johnstone, Thomas, Bothwell Collieries, Bothwell, - 1880

Keith, Daniel, Arden Lime Works, Barrhead, - - 1883
Kirkpatrick, Alexander, Allanshaw, Hamilton, - - 1884

Laird, Andrew, 1 Corunna Street, Glasgow, - - 1883
Landale, David, The Binn, Burntisland, - - - 1883
Law, Alexander, 5 Millbrae Terrace, Langside, - - 1880
Lewin, Henry W., Drumpellier, Coatbridge, - - 1882

M'Callum, Alexander, 9 Pitt Street, Edinburgh (Member of Council), - - - - - 1880
M'Cosh, Andrew K., Gartsherrie Iron Works, Coatbridge, 1881
M'Creath, George W., 95 Bath Street, Glasgow, - - 1879
M'Creath, James, 95 Bath Street, Glasgow (President), - 1879
M'Culloch, John, Monkland Iron and Coal Works, Airdrie, 1879
Macdonald, John, Haughhead Colliery, Hamilton, - 1879
Mackay, Andrew, Grangemouth Coal Co., Grangemouth, - 1879
M'Kenzie, Kenneth, New Bank Colliery, New Cumnock, - 1880
M'Kenzie, William, Newbattle Collieries, Dalkeith, - 1880
M'Lauchlan, J. D., Viewforth Manse, Edinburgh, - 1882
M'Lean, Andrew, Hill Colliery, Netherburn, by Hamilton, 1880
M'Nab, John, Flemington Coal Co. (Limited), Cambuslang, 1881
M'Naughton, James, 11 West Regent Street, Glasgow, - 1880
M'Whirter, William, 219 Argyle Street, Glasgow, - 1883
Marshall, R. A., 170 Hope Street, Glasgow, - - 1879
Meiklejohn, John, Westfield Iron Works, Dalkeith, - 1879
Miller, Archibald, Wood Merchant, Motherwell, - - 1881

Mitchell, George A., 67 West Nile Street, Glasgow, - 1881
Moffat, James, 10 Bothwell Street, Glasgow, - - 1883
Moffat, Peter, 16 Ure Place, Montrose Street, Glasgow, - 1881
Moore, Robert, T., 134 St. Vincent Street, Glasgow (Member of Council), - - - - 1880
Morison, John, Newbattle, Collieries, Dalkeith, - - 1879
Morton, James, Langloan Iron Works, Coatbridge, - 1880
Mungall, Henry, Cowdenbeath Collieries, Cowdenbeath, - 1880
Munroe, H. S., H. Grevel, 33 King Street, Covent Garden, London, W.C. - - - - - 1881
Munro, R. D., 162 Buchanan Street, Glasgow, - - 1883

Nasmyth, A. H., Donibristle Colliery, Crossgates, Fife, - 1880
Nasmyth, J. A., Donibristle Colliery, Crossgates, Fife, - 1880
Neilson, George, Summerlee Iron Works, Coatbridge, - 1883
Neilson, John, Summerlee Iron Works, Coatbridge, - 1883

Ormiston, A. R., 19 Waterloo Street, Glasgow, - - 1880
Ormiston, James, Mount Vernon, Glasgow, - - 1880

Paterson, Thomas, 95 Bath Street, Glasgow, - - 1883
Paul, James, Wilsontown House, Wilsontown, - - 1879
Percy, C. M., 25 King Street, Wigan, - - - 1882
Pickering, John, 54 West Regent Street, Glasgow, - 1883
Pollock, William, 88 Great Clyde Street, Glasgow, - 1883
Pratt, George, 29 Waterloo Street, Glasgow, - - 1879
Prentice, Joseph, Addiewell Colliery, West Calder, - 1880

Rankine, David, 75 West Nile Street, Glasgow, - - 1879
Reid, John, Loanhead House, Baillieston, - - - 1881
Reid, John, jun., 74 Bath Street, Glasgow, - - 1883
Robertson, David, 21 Pitt Street, Glasgow, - - 1880

Robertson, D. A. W., Glenbank, Lenzie, - - - 1882
Robertson, William, 123 St. Vincent Street, Glasgow, - 1879
Robson, J. T., Cambuslang (Vice-President), - - 1878
Ronaldson, John M., Belton Villa, Pollokshields (Past Vice-President), - - - - - 1879
Ross, John, Benhar School, Whitburn, - - - 1882
Rowan, Fred. J., 134 St. Vincent Street, Glasgow, - 1883
Roxburgh, Alexander, Alloa Coal Company, Alloa, - 1880
Roy, William, Limerig and West Drumclair Collieries, Slamannan, - - - - - 1879
Russell, Archibald, Jun., Roslin, Edinburgh, - - 1882
Russell, George, Summerlee Iron Works, Coatbridge, - 1883
Russell, Robert, Coltness Iron Works, Newmains, - 1878

Schuman, Sig., 4 North Court, Royal Exchange, Glasgow, 1880
Scott, John, Calder Iron Works, Coatbridge, - - 1879
Seligmann, Alfred H., 27 St. Vincent Place, Glasgow, - 1883
Simpson, Alexander, Albert Road, Pollokshields, - - 1878
Smart, James, Angus Lodge, Hamilton (Vice-President), - 1879
Smith, George W., Port Elizabeth, South Africa, - - 1883
Speirs, Alexander, Jun., 28 St. Enoch Square, Glasgow, - 1879
Spencer, Andrew, 160 Hope Street, Glasgow, - - 1883
Spowart, Thomas, Broomhead, Dunfermline, - - 1881
Stevenson, Graham, Airdrie Engine Works, Airdrie, - 1879
Stevenson, John, Lilliehill House, Dunfermline, - - 1881
Stewart, Alex., Tharsis Mines, Huelva, Spain, - - 1879
Stewart, Robert, 1 Dixon Street, Glasgow, - - 1883
Stewart, Thomas P., Hydepark Rope and Sail Works, Glasgow, - - - - - - 1884

Taylor, Lachlan, Brass Foundry, Hamilton, - - 1879
Terris, Henry, Clackmannan Colliery, Clackmannan, - 1880
Thomas, Shenton, Blantyre Collieries, High Blantyre, - 1879
Thomson, Alex., 112 Bath Street, Glasgow, - - 1880
Thomson, Charles, Calder Iron Works, Coatbridge, - 1879
Thomson, James, Meldrum's Mill, Dunfermline, - - 1883
Thomson, Robert D., Jerviston House, Motherwell, - 1883
Thomson, Samuel, Jerviston House, Motherwell, - - 1879
Thornton, James, Hermand House, West Calder, - 1883
Thornton, Peter, Crofthead, Fauldhouse, - - - 1878
Thornton, Thomas, Auchinheath Colliery, Lesmahagow, - 1879
Topping, R. M., Blantyre Foundry, Blantyre, - - 1879
Torrance, James W., 69 Buchanan Street, Glasgow, - 1881

Ure, John Y., Udston Colliery, Hamilton, - - 1879

Waddell, James, Mauldslie Colliery, Carluke, - - 1879
Waldie, James, 103 Leith Walk, Leith, - - - 1882
Waldie, James F., Legbranock Collieries, Holytown, - 1883
Walker, James, 66 Waterloo Street, Glasgow, - - 1883
Walker, James P., Dalmellington Iron Works, Ayrshire, - 1880
Walker, William H., 3 Kerseland St., Hillhead, Glasgow, 1880
Wallace, James, Wester Gartshore Colliery, Kirkintilloch, 1882
Watson, John, Earnock, Hamilton, - - - 1879
Weir, Alexander, Broomhill Drive, Partick, - - 1881
Weir, William, Caldercruix, Airdrie, - - - 1881
Whitelaw, Thomas, Dalziel Colliery, Motherwell, - 1879
Williams, Thomas E., Camp Colliery, Motherwell, - 1880
Williamson, John R., 12 St. Andrew Square, Edinburgh, - 1882

Wilson, Andrew, Dalzell Estate Office, Motherwell, - 1880
Wilson, Andrew M., Glorat, Milton of Campsie, - - 1880
Wilson, John, Alderston, Mid-Calder, - - - 1881
Wilson, John, Dechmont Lodge, Bothwell, - - 1879
Wilson, William, Walmer House, Dunfermline, - - 1883
Wood, James, 40 St. Enoch Square, Glasgow, - - 1880
Wylie, John, Clifton Iron Works, Coatbridge, - - 1883

Young, John, Baljaffray Colliery, New Kilpatrick, - 1881
Young, Robert, 37 West George Street, Glasgow,- - 1882

ORDINARY MEMBERS.

Subscription, 10s 6d.

Allan, John, Calder Iron Works, Coatbridge, - - 1881
Allan, Robert, Gartnavel, Maryhill, - - - 1880
Allan, William, Woodyett and Dennymill Mines, Denny, - 1881
Allardice, James, Eastfield Colliery, Cambuslang, - - 1881
Anderson, David, Cowdenbeath Colliery, Cowdenbeath, - 1881
Anderson, George, Barkip Colliery, Dalry, - - 1880
Anderson, John, Lochgelly Iron and Coal Coy., Lochgelly, 1880
Anderson, Thomas, Milnwood Cottage, Mossend, - - 1881
Andrew Robert, Muircockhall Colliery, Dunfermline, - 1880
Andrew, William, Lassodie Colliery, Dunfermline, - 1880
Archibald, William, Clippens Colliery, Johnstone, - 1879
Arnott, Thomas, Summerlee Iron Works, Coatbridge, - 1879

Bain, Hugh, Uppertown Cottage, by Airdrie, - - 1883
Ballantyne, James, Craigrigg Colliery, Woodend, Bathgate, 1882
Baxter, Robert, East Benhar Colliery, Fauldhouse, - 1880
Beveridge, James, Kelty Colliery, Blairadam, - - 1881
Begg, John, Whitehill Colliery, Rosewell,- - - 1879
Beith, Robert, Townlands Colliery, Hamilton, (Member of Council), - - - - - - 1878
Beveridge, James,- - - - - - 1882
Blyth, Archibald, Bent Colliery, Hamilton (Member of Council), - - - - - - 1878
Borrowman, James, Hilltop Colliery, Stoke-on-Trent, - 1881
Bowie, Hunter, Lugar Iron Works, Old Cumnock, - 1881

Brown, George, Longriggend Colliery, Airdrie, - - 1880
Brown, Peter, Schoolhouse, Rawyards, Airdrie, - - 1881
Brown, Robert, Cadzow Colliery, Hamilton, - - 1883
Brown, William, Newton Colliery, Newton, - - 1883
Brownlie, Archibald, Lassodie, Colliery, Dunfermline, - 1883
Bryden, David, Coylton, Ayr, - - - - 1881

Calderwood, Robert, Oakbank Shale Works, Mid Calder, 1880
Campbell, Alexander, Burgh Colliery, Irvine, - - 1882
Campbell, Thomas, Cleland Colliery, Newarthill, Motherwell, - - - - - - 1881
Campbell, William, Kingseat Collieries, Dunfermline, - 1883
Carey, William, Grange Colliery, Bo'ness, - - 1882
Carmichael, Robert, Earnock Colliery, Hamilton, - - 1880
Christison, Robert, Durhamtown, Bathgate, - - 1880
Clarke, J. A., Ayr Colliery, Ayr, - - - - 1880
Clelland, James, Carronhall Colliery, Falkirk, - - 1879
Cochrane, Joseph, Newton Colliery, Newton, - - 1883
Cochrane, Neil, Auchinheath Colliery, Lesmahagow, - 1881
Colquhoun, Robert, 66 South Bridge Street, Airdrie, - 1882
Cook, Robert, Church Street, Sunnyside, Coatbridge, - 1881
Cowie, George, Springwells Colliery, Airdrie, - - 1879
Cranston, David, Woodend Colliery, Armadale, - - 1880
Crichton, A. H., Uphall Mineral Oil Co., Uphall, - 1880
Crockett, John D., Bleachfield Brick Works, Falkirk, - 1880
Crookston, Andrew, Wemyss Colliery, by Dysart, Fife, - 1880
Crookston, Thomas, Drumpellier Colliery, Coatbridge, - 1879
Cunninghame, Archibald, Eglinton Iron Co., Dalry, - 1881
Cuthbert, Robert, Gauchalland Colliery, Galston, - 1881

Danks, Henry, Green Colliery, Wishaw, - - - 1880
Dewar, Peter, Braidwood Colliery, Carluke, - - 1878
Dewar, Robert, Harthill Colliery, Whitburn, - - 1881
Dewar, Thomas, Glenoleland Colliery, Wishaw, - - 1881
Drinnan, John, Arden Colliery, Airdrie (Member of Council), - - - - - 1880
Duncan, George, Leven Colliery, Leven, - - - 1881
Dunsire, Andrew, Cameron Colliery, Windygates, - 1883

Easton, Alex., Haywood Colliery, Lanark, - - 1883
Erskine, George, Lochgelly, Fife, - - - - 1881

Falconer, Thomas, - - - - - 1880
Faulds, Alexander, Dalzell Colliery, Motherwell, - - 1878
Ferguson, David, Hematite Iron Works, Harrington, Cumberland, - - - - - 1878
Ferguson, Duncan, Lochore and Capeldrae Collieries, Lochgelly, - - - - - - 1880
Forgie, James T., Craigston Square, Lugar, Old Cumnock, 1878
French, John, Millcroft Cottage, Rutherglen Road, Glasgow, - - - - - - 1879
Fulton, David, Dalquharran, Maybole, - - - 1881

Gardiner, Thomas, Jun., Auldton Collieries, Dalserf, - 1881
Gavin, James, Carfin Colliery, Motherwell, - - 1880
Gemmel, James, Govan Colliery, Glasgow, - - 1878
Gibb, Robert, - - - - - - 1881
Gilchrist, Hugh M., Rapid City, Rock Island County, Illinois, U.S.A., - - - - - 1882

Gilchrist, James, Earnock Colliery, Hamilton (Member of Council), - - - - - - 1878

Gillon, William, Kinneil Iron Works, Bo'ness, - - 1881

Goodwin, James, Gartness Coal Co., Airdrie, - - 1883

Gordon, Gavin C., Knightswood Colliery, Maryhill, - 1878

Grant, John, Bog and Home Farm Collieries, Larkhall, - 1878

Grant, Robert, - - - - - - - 1881

Gray, William, Lugar Iron Works, Old Cumnock, - 1880

Green, William, Galston Colliery, Galston, - - 1883

Haddow, John, Arniston Colliery, Gorebridge, - - 1879

Hamilton, James, 14 Burnbank Terrace, Hamilton, - 1883

Hardie, James, Benhar, Whitburn, - - - 1882

Hart, James, Duchray Colliery, by Ayr, - - - 1880

Hart, John, Clyde Iron Works, Tollcross, - - 1881

Hastie, James, Greenfield Colliery, Hamilton (Member of Council), - - - - - - 1879

Hastie, William, Gilmilnscroft, Auchinleck, - - 1881

Henderson, Andrew, Muiravonside Colliery, Bowhouse, Linlithgow, - - - - - 1880

Herd, Peter, Dunnikeir Colliery, Kirkcaldy, - - 1880

Herd, Thomas, Dunnikeir Colliery, Kirkcaldy, - - 1880

Hill, James, Townlands Colliery, Hamilton, - - 1880

Hillhouse, William, Bonnyton Cottage, Kilmarnock, - 1883

Hogg, John, North Motherwell Colliery, Motherwell (Member of Council), - - - - 1880

Hogg, William, Carnmoor Cottage, Forth, by Lanark, - 1881

Howat, John T., Titwood Cottage, Pollokshaws, - - 1883

Howie, James, Priestfield Terrace, High Blantyre, - 1883

Hunter, A., Alloa Colliery, Alloa, - - - - 1880
Hunter, Andrew, Orbiston Colliery, Bellshill, - - 1878
Husband, John, Kirkwood Colliery, Coatbridge, - - 1881

Ireland, Thomas, Largoward, St. Andrews, - - 1881

Jackson, Douglas, Ross Colliery, Hamilton, - - 1880
James, William, Niddrie Colliery, Portobello, - - 1883
Jamieson, Robert, Polkemmet Cottage, Bathgate, - 1881
Jamieson, William, Addiewell Oil Works, West Calder, - 1879
Jeffrey, Andrew, Rankinston Colliery, Patna, - - 1880
Johnstone, Hugh, Niddrie Collieries, Portobello, - - 1879

Kennedy, Alexander, Broxburn Oil Works, Broxburn, - 1882
Kerr, Archibald,* Barncluith Colliery, Hamilton, - - 1881
Kerr, Archibald, 21 John Street, Hamilton (Librarian), - 1881
Kirkwood, Archibald, Dalzell Colliery, Motherwell, - 1878
Kirkwood, William, Shottstown, Penicuik, - - 1880
Knox, James, Allanton Colliery, Newmains, - - 1880

Langlands, John, - - - - - 1878
Legat, A. S., Loanhead Colliery, Edinburgh, - - 1879
Leggete, John, Birkenshaw, Larkhall, - - - 1881
Lithgow, Thomas, Langbyres Colliery, Omoa, Motherwell, 1882
Livingstone, Archibald, Glencavil, Ballymena, Ireland, - 1880
Loudon, John, Burntisland Oil Co., Burntisland, - 1879
Love, John, Haughhead Colliery, Hamilton (Member of Council), - - - - - - 1878
Love, John, Portland Iron Works, Hurlford, - - 1882
Love, William J., Shotts Iron Coy., Shotts, - - 1881

* Deceased.

M'Beth, Peter, Callander Coal Co., Falkirk, - - 1879
M'Cairn, Nicol, Prestonlinks, Prestonpans, - - 1881
M'Culloch, William, Linkieburn House, Muirkirk, - 1881
M'Donald, John, Greenhill Colliery, Holytown, - - 1880
Macdonald, Symington, The Nickel Co., Noumea, New Caledonia (via Brindisi), - - - -
M'Gowan, John, Gilmerton Colliery, Liberton, - - 1883
M'Farlane, Malcolm, Govan Colliery, Glasgow, - - 1878
M'Farlane, Walter, West-end Cottage, Chryston, - - 1882
M'Feddris, William, Tannochside Colliery, Uddingston, - 1880
M'Gee, John, Tillicoultry Colliery, Tillicoultry, - - 1880
M'Kay, James, Roughrigg Colliery, Airdrie, - - 1880
M'Laren, Robert, Rawyards Colliery, Airdrie, - - 1882
M'Neil, James, Maryville Colliery, Uddingston, - - 1878
M'Neil, Robert, Blackhill Colliery, Bishopbriggs, Glasgow, 1878
M'Pherson, Gilbert, Trabboch Colliery, Coylton, Ayr, - 1881
Makepeace, Hugh R., Calderbank, Airdrie, - - 1881
Malcolm, James, Craigneuk Colliery, Motherwell, - 1879
Martin, Robert, Pentland Oil Works, Loanhead, - - 1879
Martin, William, Douglas Park Colliery, Bellshill, - 1881
Mathie, James, Cornsilloch Colliery, Larkhall, - 1879
Maxwell, James, Limerigg Colliery, Slamannan, - - 1882
Millar, William, Townlands Colliery, Hamilton, - - 1883
Moodie, Thomas, Devon Colliery, Alloa, - - - 1881
Morton, John, Auchenharvie Colliery, Saltcoats, - - 1880
Morton, R. M., Ansonhill House, Crossgates, Fife, - 1879
Muir, James, Wishaw Iron Works, Wishaw, - - 1883
Muir, John C., Wishaw Iron Works, Wishaw, - - 1883

Muir, W. W., Coltness Colliery, Newmains, - 1878
Munro, James, Quarter Iron Works, Hamilton, - - 1879
Murray, John, Greengairs, Airdrie, - - - 1879

Napier, John, Haywood Colliery, Lanark, - - 1883
Nasmyth, A., Donibristle Colliery, Crossgates, Fife, - 1880
Neilson, Benjamin, Niddrie Colliery, Portobello, - - 1880
Neish, George, 49 Bardowie Street, Possil Park, Glasgow, 1879
Ness, Henry, Benarty Colliery, Blairadam, Kelty, - 1880
Nimmo, Thomas, Fauldhouse Colliery, Fauldhouse, - 1879

Orr, Thomas, Morningside Colliery, Newmains, - - 1881
Osbourne, Michael, Blantyre Colliery, Blantyre, - - 1883

Park, James, Wellhouse, Rutherglen, - - - 1883
Park, John, Stonelaw Colliery, Rutherglen, - - 1881
Park, Joseph, Allanshaw Colliery, Hamilton, - - 1878
Paterson, Hugh, Braidhurst Colliery, Motherwell, - 1881
Paul, James, Law Colliery, Carluke, - - - 1881
Penman, James, Woodside Cottage, Harthill, Whitburn, - 1883
Penman, William M., Blairengone Colliery, Dollar, - 1881
Pettigrew, Robert, 66 Flowerhill Street, Airdrie, - - 1881
Phillips, John, Easter Moffat Colliery, Airdrie, - - 1880
Pitcairn, Gilbert, Eddlewood Colliery, Hamilton, - - 1880
Prentice, James, Stanrigg Collieries, Airdrie (Member of Council) - - - - - - 1881
Prentice, Thomas, Addiewell Works, West Calder, - 1879
Prentice, William, Dalmellington Iron Co., Ayrshire, - 1879
Pringle, James, Govan Colliery, Glasgow, - - - 1880

Rankine, John, Drumgray Colliery, Airdrie, jun., - - 1881
Rigg, Thomas, Doura Colliery, Kilwinning, - - 1883
Ritchie, Alex., Cleland Colliery, Newarthill, . - 1881
Ritchie, Robert, Kilsyth Coal Coy., Kilsyth, - - 1883
Robertson, Alex., Benwhat, Dalmellington, - - 1880
Robertson, Archd., Bathville, Colliery, Armadale, - 1880
Robertson, David, Dalquharran Colliery, Maybole, - 1881
Robertson, James, Braehead, Baillieston, - - - 1881
Robertson, John, 10 Bellgrove Street, Glasgow, - - 1880
Robertson, John, Lanemark Colliery, New Cumnock, - 1880
Robson, Robert, Breich Shale Pits, West Calder, - - 1882
Ronaldson, James H., Trabboch Colliery, Coylton, Ayr, - 1879
Rorison, John, Springhill Colliery, Kilmarnock, - - 1883
Ross, Alexander, Glenhead, Camp, Motherwell, - - 1880
Ross, James, Bathgate Oil Coy., Seafield, Bathgate, - 1878
Ross, Michael, Clyde Bridge, Hamilton (Treasurer), - 1878
Rowan, Henry, Avondale Cottage, Uddingston, - - 1881
Russell, Alexander, Dalmeny, Edinburgh, - - 1883
Russell, James, Elgin and Wellwood Collieries, Dunfermline, - - - - - - 1880
Russell, W. S., Broxburn Oil Coy.'s Works, Broxburn, - 1880

Scobie, William, Gilbertfield Colliery, Cambuslang, - 1881
Semple, William, Jun., Crosby and Gilcruix Collieries, Maryport, Cumberland, - - - - 1880
Semple, William, Sen., Goatfoot Colliery, Galston, - 1881
Sharp, A., Sheardale Colliery, Tillicoultry, - - 1880
Sharpe, George, Wilsontown Colliery, Lanark, - - 1881
Simpson, Dundas, Ellismuir Colliery, Baillieston, - 1879

Simpson, James, 43 Dalzell Street, Motherwell, - - 1881
Sloss, James, Auchlochan Collieries, Lesmahagow, - 1881
Smith, Hamilton, Cadzow Colliery, Hamilton, - - 1878
Smith, James, Jun., Craigstone Cottage, Lugar, - - 1881
Smith, John, Cannock Lodge Colliery, Bloxwich, Staffordshire, - - - - - - 1878
Smith, John, Rosehall Colliery, Coatbridge, - - 1880
Somerville, William, Bredisholm Colliery, Uddingston, - 1880
Stevenson, Robert, - - - - - 1883
Stewart, H., Tranent Colliery, Tranent, - - - 1881
Stewart, Robert, Legbranock Collieries, Holytown, - 1883
Stirling, John, Bonnybridge, - - - - 1880
Stirling, Walter, - - - - - - 1880
Strain, Hugh, 3 Clark Street, Airdrie, - - - 1879

Telfer, Henry, Overtown Colliery, Carluke (Member of Council), - - - - - - 1878
Thom, Archibald, Twechar, Kilsyth, - - - 1881
Thomas, Davey, - - - - - - 1881
Thomson, Abram, Hareleeshill, Larkhall, - - - 1880
Thomson, A. M'D., West Limerigg Co., Slamannan, - 1880
Thomson, John, Stevenston Colliery, Holytown, - - 1880
Thomson, Richard, 231 Saracen Street, Possil Park, Glasgow, 1878
Thomson, Thomas, Balquhatston Colliery, Slamannan, - 1879
Turner, William, Chapel Colliery, Newmains, - - 1881
Twaddle, William, Ferniegair, Hamilton, - - 1878

Waddell, Alexander W., Kinneil Iron Works, Bo'ness, - 1883

Waddell, Robert, Blackston Works, Paisley, - - 1880
Walker, David, Garscadden Works, Bearsden, - - 1880
Walker, Robert, Bog Colliery, Larkhall, - - 1881
Walker, William, Rigside Colliery, Douglas, - - 1880
Wardlaw, John, Garriongill Colliery, Wishaw, - - 1878
Wardlaw, Robert, Salsburgh, Holytown, - - - 1883
Wardrop, John, Woodside Colliery, Carluke, - - 1879
Watson, Thomas, Jun., Craignethan Colliery, Lanark, - 1880
Webster, David, Burdie House Lime Works, Edinburgh, - 1880
Williams, John, 16 Blanche Street, Dowlais, South Wales, 1884
Williamson, James, M'Lean's Land, Dunbeth Road, Coatbridge, - - - - - 1880
Wilson, James, Haywood Colliery, Lanark, - - 1880
Wilson, Robert, Longrigg Colliery, Slamannan, - - 1880
Wilson, Robert, Eastgrange, by Culross, - - - 1880
Wilson, Thomas, Eastplean Colliery, Bannockburn, - 1880
Wilson, William, Auchinraith Colliery, High Blantyre, - 1879
Wilson, William, Dykehead Colliery, Larkhall, - - 1880
Wilson, William, Pumpherston Oil Coy., Uphall Station, - 1881
Winning, Andrew, New Farme Colliery, Rutherglen, - 1882
Wyllie, James, Townhill Colliery, Dunfermline, - - 1880
Wyper, James, Mauldslie Colliery, Carluke, - - 1880

Yates, Andrew, Bellfield Colliery, Hurlford, - - 1881
Young, James, Quarter Iron Works, Hamilton, - - 1882
Young, Robert, Thankerton Colliery, Holytown, - - 1880

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